MORE THAN WORDS: CO-CONSTRUCTIVE DIALOGUE AS A STRATEGY FOR TECHNICAL, ACADEMIC LANGUAGE ACQUISITION (TALA) IN AN INDIGENOUS, MIDDLE SCHOOL SCIENCE CLASSROOM

By

Joachim H. Ladwig, B.S.

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of

Master of the Arts

in

Applied Linguistics

University of Alaska Fairbanks

May 2019

APPROVED:

Leslie Patterson, Committee Chair
Sabine Siekmann, Co-Chair
Wendy Martelle, Committee Member
Patrick Marlow, Program Chair
Linguistics Program
Todd Sherman, Dean
College of Liberal Arts
Michael Castellini, Dean
Graduate School

Abstract

This teacher action research study investigated how secondary science students respond to small group co-construction activities designed to help them produce collaborative summaries of scientific information. The principle research question guiding this study asks, "How do middle school students engage in content learning and in the use of technical academic language (TAL) during a science writer's workshop?" Building upon the work of previous investigators I studied how emerging bilingual Grade 8 students participated in a science writer's workshop as they co-constructed written summaries in small groups. After initial instruction about the science content, participants worked in table groups to begin their summaries and become comfortable with the process. Participants were regrouped for the final phases of the workshop as they revised their earlier work. Twelve classroom sessions were digitally recorded and from them 25 language-related episodes (LREs) from two small groups were identified for further investigation. LREs were transcribed and analyzed for patterns of student interaction and then correlated with students' written summaries. These deeper interaction patterns became the targeted categories of this investigation: teaming; going beyond the content; and disagreeing. Each of these patterns provide different opportunities for students to learn more about the science content and to use scientific language. The extra time for this collaboration allowed for more TAL usage and seemed to make a meaningful difference in these students' final writings. Further, analysis reveals that TALA is a complex sociocultural process and that the dialogic process inherent in the science writer's workshop is more important than the words alone. In this context, dialogue about science in the context of the science writer's workshop supported both content learning and the acquisition of TAL for these emergent bilingual middle school students.

Table of Contents

Page

List of Figures

List of Tables

List of Transcript Excerpts

List of Writing Excerpts

Table of Appendices

Acknowledgements

With the deepest gratitude I acknowledge this journey would not have been taken, and this thesis would not have been written without the generous support of my champions; faculty, colleagues, administrators, students, and family. All thoughtful, helpful people.

My Professors have provided encouragement from the pre-LEB introductions meeting to this successful end. Committee Chair, Leslie Patterson, has welcomed me into this new field of study and asked “Now what?” She introduced me to Rosenblatt’s poem and kept me actively tending to the foibles of my writing style. Sabine Siekmann introduced me to Vygotsky and forwarded numerous articles to intrigue a scientist, coincidentally another Joachim, of Kimmerle et al. (2017), a core author in the literature review. She helped me validate narrower data sets and has always smiled while pressing me to look deeper to consider nuanced, emerging perspectives in the data. Wendy Martelle has shared educational philosophies, meditation, and a common connection with the Russian people. She has offered thoughtful organization when it seemed I had none and calming moments when I most certainly needed grounding. Thank you.

My LEB secondary education colleagues have been collaborators in our mutual success. I am proud to do the shuffle with all of my LEBers and grateful for my brilliant associates.

My supportive colleagues and administrators at the Lower Yukon School District have carried out many of my “other duties as assigned” through these heavily tasked years of graduate school. Your counsel that my work resonates with other teachers and gentle reminders that I should take a little walk on the tundra now and again have made a world of difference.

My amazing, resourceful, 8^{th} graders who shared their excitement, discoveries, and frustrations to make science learning more accessible for those coming up behind you. I could not have accomplished this goal without the trust and support of each of you. Thank you.

Finally, my family has been around the world with me in spirit since I began this global whirlwind of teaching and learning near the edge. My extraordinary wife Katrina has made working away from home possible and even comfortable while keeping me connected with our families, our children, and our grandson. My brother Jon has shouldered parental support duties back home, helped keep my head clear of those worries, and reminded me of the value of family. Jacqui, my doctoral candidate sister, has commiserated over the pains of graduate school, traveled thousands of miles in support of our parents, and reminded me where home is.

As I pen these last remarks I remember my parents. You encouraged me to venture out, continue my studies and adventures, and cheerfully awaited my calls and visits. You pushed me to fly on ahead knowing that I had your support. You plotted my location on the map and helped me chart my course. Your advice to "be as kind as I can, as often as I can" has changed lives. Godspeed Mom and Dad. I carried you all with me to guide the way on this road less traveled, and that has made all the difference. Thank you all.

Chapter 1: Introduction

In 2010 I arrived in Manama, Bahrain, a seasoned American School science teacher ready to share the sciences with my new bilingual Arab-English speaking students. I believed I was prepared and planned to use the successful methods I had used for years in Indiana and I pressed forward with science, rigorously, in English (and Greek, and Latin). I did what I thought good science teachers would do to build scientific understanding in their students. I taught them science content. My students were Bahraini, Korean, South African, Syrian, and Turkish, including the Ambassador's native English speaking son and daughter. In the beginning I struggled without truly successful methods in teaching my International Baccalaureate, Middle Years students.

In my third year in Arabia, a huge placard was posted in the teachers' workroom above the windows through which my colleagues and I could look down into the students' enormous, circus-tented yard. It read, "ALL TEACHERS ARE LANGUAGE TEACHERS." I believed that and was reaching out to do what I thought good science teachers would do to build English capacity in our students, I taught them science words using more, familiar language. Our highly regarded, multi-national science faculty worked to employ literacy strategies to teach scientific language to middle schoolers. I began to change my modus operandi, investigating methods to connect science content to my students using more language.

Today, after three years as a teacher researcher in an Alaskan bush community, I continue to investigate how students respond when I attempt to integrate literacy objectives with science content. My latest integration of literacy with content is the science writer's workshop. I am wondering, how do I best build capacity for technical, academic language in my middle school students' minds? This led me to my research question "How do middle school students engage in content learning and in the use of TAL during a science writer's workshop?"

The Significance of This Study

As of the most recently published data (State of Alaska, 2012) Alaska Education and Early Development division has seen few real gains in literacy within bush populations. Each year more students drop out or graduate from bush schools with a half-filled linguistic skill box. The *Alaska Career Ready Factsheet* (State of Alaska, 2012) research has calculated that in the modernized work force, "81% of the available jobs beyond the bush community require post-secondary education" (NP). It goes on to say that, "far too many students drop out or graduate from high school unprepared for success, closing doors and limiting their options and opportunities—in particular minority and low-income students" (NP). Two widely accepted conclusions are:

- Low literacy is a high contributor to poor attendance and high dropout rates, and,
- Students not mastering academic language in high school are unprepared for academic options or family-supporting employment options beyond the village horizon/village life/subsistence living (State of Alaska, 2012).

Low literacy, particularly the use of academic or technical language, is a high contributor to this unhealthy situation. Should graduates choose to pursue life beyond the village, they are counting on teachers' instruction in critical thinking and academic literacy to carry them there. Higher quality, more authentic, technical academic language acquisition (TALA) practices have the potential to improve student success.

Although many researchers assert that language acquisition requires social interactions over time (Lantolf & Thorne, 2007; Storch, 2002; Vygotsky, 1978), history shows a tendency for academia in general (including science teachers) to fill large classrooms of students with single source, fact-based "knowledge" that must be quickly memorized, replacing whatever a student thought they knew. This is the banking model concept of learning.

I believe that the banking model, which asserts that ideas are encoded clearly in the mind of the sender and are transmitted into the mind of the recipient (Freire, 1970), quietly persists across academia in general and science classrooms in particular. The banking model mindset contributes to large amounts of rote memorization, heavy problem set-based homework loads, lower student engagement, and a dislike of science education. Freire challenged the model's "acts of depositing" (p. 72), where teachers neatly fill the empty minds of students, as a legitimate mechanism for information transfer. Freire opposed the banking model calling for an interactive pursuit of the truth because education is liberating and "must be revolutionary—that is to say, dialogical—from the start" (p. 86). I too believe that the interactive pursuit of truth is the way of science and science teaching.

In Summer 2016, I joined in a joint teacher action research (TAR) project through a Department of Education grant and in conjunction with the University of Alaska-Fairbanks, the Literacy for Emerging Bilingual learners program (LEB). As a part of that TAR, I designed a research project that would assess the activities of a science writer's workshop in Mountain Village School's Grade 8 science class as they discussed the required scientific content in the Spring semester of 2018. This thesis is a discussion of that science writer's workshop project.

The remainder of this thesis consists of a review of the literature, discussion of the methodology of the study, analysis of the study's data, and a conclusion which uses the literature to frame the data analysis.

Chapter 2, the Literature Review, highlights the research and current theory that informs the study and the process of designing the science writer's workshop itself. The chapter discusses four facets of the field of linguistic research that relate directly to this study: A Sociocultural Approach to Science Language Learning, Language as a Tool for Scientists, Language Learning is Social and Involves Collaborative Dialogue, and finally, Language and Literacy as Mediational Tools: Even in a Science Classroom.

Chapter 3, Research Methodology, provides an overview of the methodology of the study. I discuss the research design in this study, teacher action research (TAR). Analysis of this TAR is discussed within the analytic framework of constructivist grounded theory (CGT). The chapter includes a description of the setting, the participants, and the research procedures.

Chapter 4, Research: Data Analysis and Findings, showcases my analysis of the data collected in this study. Using the processes of CGT I coded students' actions during the workshop sessions and coded them again in search of emergent themes. Analysis was done with the students' dialogue and also with the students' written artifacts. Three main themes and four sub-themes emerged from my analysis. The chapter ends recognizing that these themes in the dialogue are intertwined with themes in students' writing and the social dynamic of the group and as such cannot be truly evaluated in isolation.

Finally, Chapter 5, Conclusions and Implications, addresses my views on the data and some questions for future science writer's workshop analysis projects.

Chapter 2: Literature Review

My research focuses on collaborative methods designed to produce higher quality results in my classroom, enhancing learners' technical, academic language (TAL) while engaging them in deeper content study.

This chapter, a review of the theoretical perspectives and previous findings leads both to my instructional approach and to the specific research questions guiding this TAR: How do middle school students engage in content learning and in the use of TAL during a science writer's workshop?

This chapter is organized in two major sections: 1) A Sociocultural Approach to Technical, Academic Language Acquisition and 2) Designing the science writer's workshop. The first section further addresses major assertions about this sociocultural approach in science classrooms. The second section describes the Science Writing Workshop and explains how the four theoretical assertions are applied in the workshop.

Technical Academic Language/ Acquisition

Before exploring the theoretical assumptions, it is important to define two central terms. Throughout this thesis I will discuss the work of a classroom of emerging bilingual (EB) Grade 8 scientists in an American school. When speaking of the language use in our science-specific discourse I will refer to it as technical, academic language (TAL) and the learning of it as technical, academic language acquisition (TALA). This TAL stands in contrast to the more generic "academic language" or "academic English."

My specific focus is on students' spoken and written use of TAL to better understand and to internalize the concepts and terminology of scientists. I have explicitly noted our scientific talk as TAL to separate it from the academic language of literary analysis, of cartography, geography and history, of mathematics and statistics, and others which apply aspects of academic language. As Shanahan and Shanahan (2012) compared the writing and talk of chemists, historians, and mathematicians they noted differences in the use of general academic language and a distinct, discipline-specific language focus. Their analysis of interviews and reading/ post-reading think-alouds of experts in each field showed very different patterns of language use while each was making sense of text. Though all of these academic language applications share commonalities, I believe the differences in science-specific language are worth noting, if only in the case of our specific community of EB science students.

Sociocultural Approach to Technical Academic Language Acquisition

Recent researchers and theorists suggest that the most supportive science instruction is grounded in a sociocultural approach (Casher & Stotler, 2015; Dyson, 2015; Kalantzis & Cope, 2008; Martin, 2008; Moll et al., 1992; New London Group, 1996; Smagorinski, 2013). This approach involves four major assumptions that can guide science teachers' decisions:

- Science learning happens in a sociocultural context.
- Science learners are active meaning makers.
- Language learning in science classrooms is social and involves collaborative dialogue.
- Language and literacy are mediational tools, even in science classrooms.

Science learning happens in a sociocultural context.

The first assertion of the sociocultural approach to science instruction focuses on the significance of social and cultural contexts. The making of meaning is a social act as "*human learning presupposes a specific social nature and a process by which children grow into the intellectual life of those around them* (Vygotsky's emphasis)" (Vygotsky, 1978, p. 88). That is to say that we learn to be like the people with whom we associate. We internalize their thoughts and ideas. Further, meaning is made within one's consciousness and understood through the lenses of society and of one's culture. A person's schematic view of the world around them is a sociocultural construct.

The power of a sociocultural approach to TALA is in the social and cultural contexts of student learning because science is itself a social construct. Persons have gathered and reasoned together to solve the mysteries of the universe since our human beginnings and this reasoning together as a society of thinkers has brought about the need for the sciences and for modern education as we know it. Vygotsky (1978) explained that meaning comes through language, which stems from a need to be understood and a need to understand. Language has two functions, communication (external) and understanding (internal), which combine in a sociocultural context.

Being able to think critically and communicate what we read allows us to move society forward by learning lessons from those who have gone before us. As I share the sciences with learners I sometimes encounter a so-what, "I don't know, I'm just subsistence (shrugging shoulders). . . [Western] science doesn't affect me here," attitude. Such an attitude closes the mind and makes it okay not to struggle with difficult or unwanted concepts. Although human beings each conduct ad hoc science daily, intentional scientific processes are carried out by the community of scientists, singly or in association, in answer to social and cultural needs. In the high school science classroom young scientists work together to conduct the intentional scientific process by learning the language and concrete concepts, and by conducting both thought experiments and physical experiments. This is science within a sociocultural context.

Another aspect of sociocultural contexts is multimodality. In a science classroom, meaning making is multimodal because "learning comes through many semiotic resources, language explicitly and/or visual, audio, gestural, or spatial representations of a thought, idea, or concept" (Kalantzis & Cope, 2008, p. 203). In a science classroom, then, learning experiences should be both communication-based and multimodal.

Obviously, a sociocultural approach to science teaching is culturally responsive. Though cultural ways affect meaning making for everyone, the participants in this study are EB learners in a Native/ Indigenous community. In addition, culturally responsive institutions and educators argue that culture is the lens through which one sees the world and makes meaning from it (Casher & Stotler, 2015; Dyson, 2015; Wilson, 2008). Martin (2008) explains that in the case of Indigenous peoples, "cultural knowledge is a critical component of meaning-making and comes through Aboriginal [Indigenous/Native] ways of knowing, of being, and of doing" (p. 63). These Native ways are multimodal and it is well understood that cultural narratives precede the written word.

As active meaning makers in sociocultural contexts, learners in my classroom use their funds of knowledge (Moll et al., 1992), the knowledge and resources upon which a(n) Aboriginal/ Indigenous/ Native person has built their entire worldview. Framed in personal, academic, social, spiritual, traditional, and cultural understandings and imposed schema they are the sum of all the traditional connections to the land, to the language, and to the traditions/culture of a people group or people groups, that a person enjoys. In other words, Indigenous peoples can know the world through knowing "one's stories of relatedness to [their] Ancestors, to [their] country" (Martin, 2008, p.63). EB learners, and more so remote-rural Indigenous EB learners, enter the mainstream of college-bound secondary curricula with different *funds of knowledge* than might a student raised in an urban metropolis.

Funds of knowledge = home knowledge + subsistence knowledge + social knowledge

Cultural perspective = Funds of knowledge

The cultural funds of knowledge a resilient village student brings to school can be "social, cognitive, cultural, and highly contextual" (New London Group, 1996) giving remote, rural students the advantage of being more culturally grounded in the necessary interactions of a vibrant village life while sufficiently connecting them to their local non-Native experiences. However, in her deep look into the challenges of bringing culturally appropriate pedagogy to Australian Aboriginal populations, Martin (2008) points out that due to the emergent circumstance of the Aboriginal/Indigenous student, traditional educational strategies may limit exposure to deep, academic language and methods mediating the cultural gap.

> Though [Indigenous] worldviews, knowledges, and Stories of relatedness are dynamic and evolving, and have been maintained successfully . . . this phenomenal accomplishment has not guaranteed [Indigenous people's] success in acquiring English literacy. (Martin, 2008, p. 68)

Science teachers who use a sociocultural approach search for ways to ensure that their students have opportunities to build on their funds of knowledge to support new learning.

Science learners are active meaning makers.

The second feature of a sociocultural approach to science instruction is the focus on meaning. Meaning making is the goal of science education. Science educators' students may be more successful if science educators draw on Vygotsky's sociocultural approaches to assist students in making internalized personalized meaning. Though meaning making is a deeply personal experience, meaning and consciousness itself are manifestations of the "continuing dialectical interaction between biological and sociocultural factors" (Vygotsky, 1978, p. 123).

Given his background in Marx's theory of society, Vygotsky believed that "individual developmental change is rooted in society and culture" and that, "the internalization of culturally produced sign systems brings about behavioral transformations" (Vygotsky, 1978, p. 7). As I work with my students to help them internalize the takeaways of scientific content I have chosen to integrate a social connection, collaborative dialogue, to help them make meaning, similar to what professional scientists might do. As Smagorinsky (2013) brings to the fore:

> Vygotsky emphasizes the development of human potential through social mediation, with schools providing an *exceptionally powerful* means of channeling how children think abstractly as a way to make sense of their concrete, personal engagement with the world [*emphasis mine*]. (p. 201)

The bridges built by intentionally applying culturally relevant, social mediation strategies serve the strengths of my students keeping them grounded in human commonalities and building a sense of global community right in our schoolyard. In addition, these bridges support the mastery of science content and technical, academic language.

A significant portion of Vygotsky's life work was invested in the study of meaning making in social and cultural contexts, and "there is a constant interplay between the sociocultural meaning and the meaning that is being created in the [mind of the meaning-maker]" (Mahn, 2012, p.117). The very *meaning* of meaning is abstract and difficult to define, but my focus here is on two viewpoints about learning, or how learners make meaning: the transactional model, and the design cycle.

Multiple modalities help students make meaning.

Active meaning making also involves multiple modalities. A multiliteracies approach to mediation which includes "representation of information in a number of ways that incorporate visual, spatial, gestural, linguistic, and audio" will help to activate "the funds of knowledge that [Indigenous] students bring with them to the classroom as life-world interests and knowledges" (Martin, 2008, p. 68). Such a pedagogical approach is additive, viewing Indigenous students' funds of knowledge as mediational tools to be drawn upon in the classroom and further their development, not as deficits to be overcome. In support of the value of multiliteracies in mediating culture and academic studies Cope and Kalantzis (2009) state: "Meaning expressed in one mode cannot be directly and completely translated into another" (p. 14). Applying such a diversified learning model brings together students' dissimilar literacies providing them more tools for meaning-making and personal development.

The transactional approach is a meaning making tool for teachers.

One useful approach for teachers who want to encourage students as active meaning makers is Rosenblatt's *transactional model of literary response* (Rosenblatt, 1978) which engages the idea that each person makes their own meaning from a written text at a given moment Figure 2.1. The reader arrives at the meaning making event with their present schematic perspectives and makes meaning from the linguistic symbols present. Future readings of this text with new understandings allow for a different interpretation of the unchanging text. Although Rosenblatt originally wrote about how readers transact with literary texts, this transactional model supports the process my science writers use to collaboratively consider their early written drafts to develop a more accurate final draft, each draft becoming more effective than the last. Specific texts science students might reference could be

- a physical specimen (microscope slide, fossil, physical experiment, a preserved fish, etc.)
- a published text (article, reference text, data set, etc.)
- prior drafts of writings, data summaries, personal notes, etc. as in this assignment)

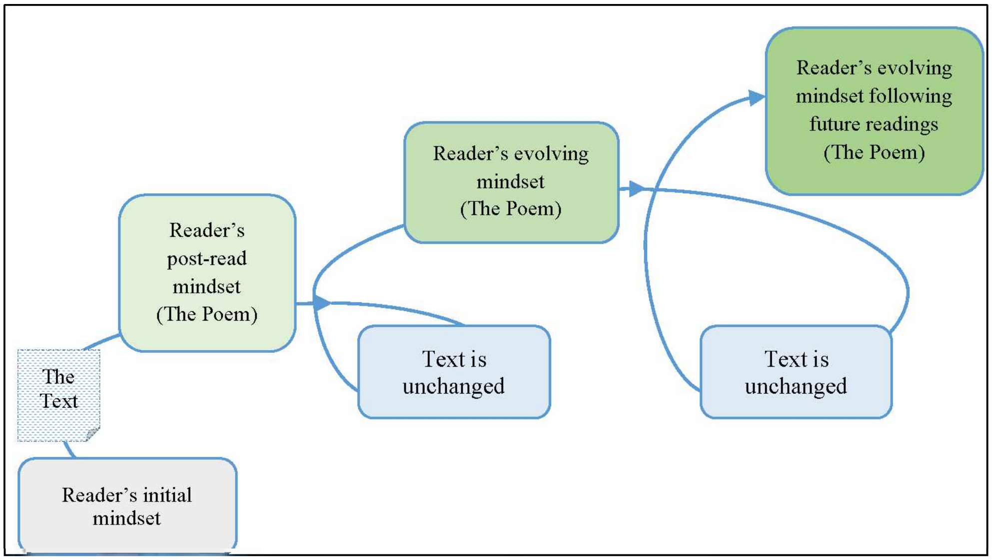


Figure 2.1: Application of Rosenblatt's (1978) transactional model to individual meaning making in the science classroom.

McKechnie (2016) states that Rosenblatt's transactional model "has some strong synergies to the work of [Vygotsky] but it doesn't specifically draw on them" (p. 57). Although Rosenblatt's transactional model is seldom cited by science educators, it clearly points to the individual learner as an active meaning maker and to the iterative, adaptive process of reading. In the study of a scientific concept, for example, a learner transacts with the phenomenon and published explanations about it (the texts) and new understandings emerge (the poem). Each time the learner re-examines the texts, there is the potential for new understandings. In science classrooms, laboratory activities and reading assignments provide learners with opportunities to transact with multiple texts as they develop their conceptual understandings of the phenomenon.

These transactions can also happen for groups of scientists as they build collective understandings. For example, in a scientific context the transactional model can be witnessed in the development of cell theory, a process which took place over 2200 years between philosophers and scientists across Eurasia. A scientific adaptation of Rosenblatt's transactional model (Figure 2.2) shows the iterative development of cell theory over time. Through the use of the written word, geographically and temporally distant collaborators built new TAL and constructed our present day understanding of life itself. Note that the living organisms (blue-toned boxes) have changed very little while our growing understanding of the science (green-toned boxes, Rosenblatt's poem) has accumulated over the millennia.

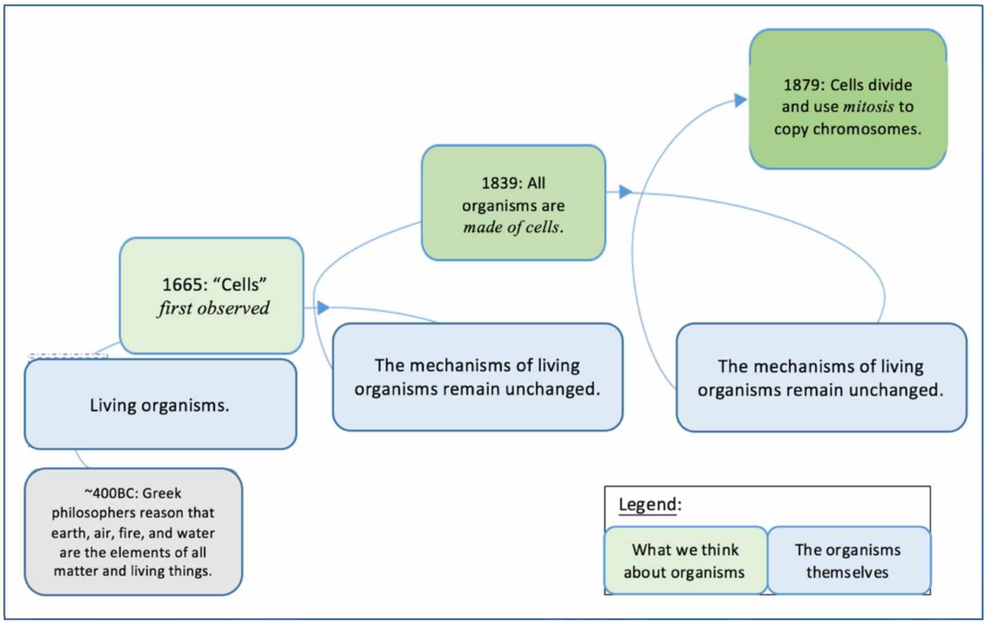


Figure 2.2: A scientific application of Rosenblatt's (1978) transactional model to collective meaning making in the scientific community.

Though the breakthroughs in scientific understanding took place over years, the studies were revisited and re-envisioned under an updated scientific perspective as those practitioners grappled with the implications of new discoveries. As philosophers and scientists studied the work of their predecessors and did their own investigations they gained a deeper understanding of the process by, metaphorically speaking, standing on the shoulders of those attempting to answer the question before them.

The design cycle is a meaning-making tool for teachers.

Another approach that is relevant to science teachers is the *design cycle* brought forward in the work of the New London Group (1996), Cope and Kalantzis (2009), and Kalantzis and Cope (2008). Cope and Kalantzis have refined the design cycle as a method of making meaning.

The underlying concept of the design cycle is that all texts (images, media or musical productions, methods/ processes, literary works, vocabulary lists, language itself, etc.) are considered to be available designs from which learners can attempt to make meaning.

In doing scientific and other forms of research, we examine a problem from different angles and redesign. We ask "are there any other ways to think about this?" (Johnston, 2012, p. 66). The redesigning of an available design, the interpreting and reapplication of the original work, is the next generation of thinking about the topic at hand. It is applying a never-before-considered adaptation of the work through a lens of newly considered understanding.

Similar to Cope and Kalantzis's design cycle, our student-centered science writer's workshop is intended to deepen TAL and concept understanding through the use of multiple conversational revisions of their views and writings in a sustained, yet relatively short-term conversational classroom experience—the science writer's workshop—using a counterbalanced methodology where TAL informs content understanding.

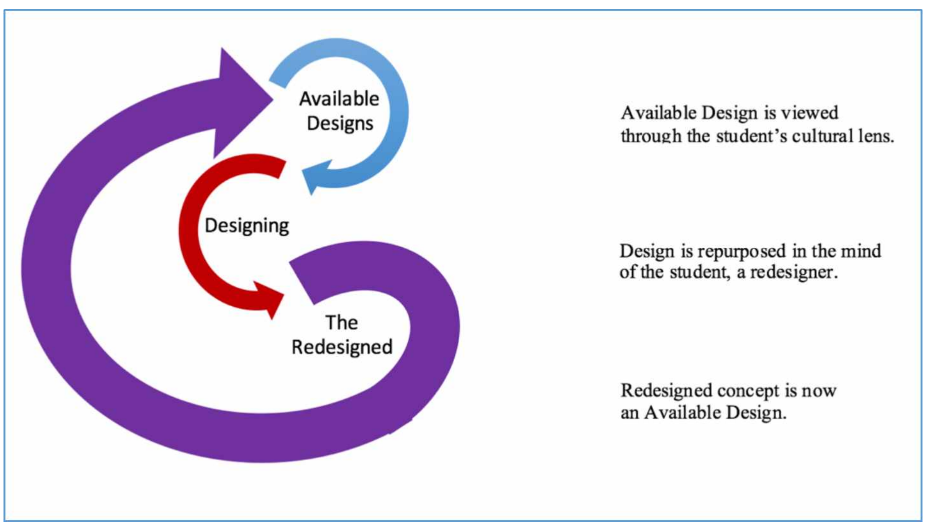


Figure 2.3: TR's interpretation of Cope and Kalantzis' Design Cycle (2009, p. 12).

In their discussion of multiliteracies Cope and Kalantzis (2009) state that "this process of transformation is the essence of learning" and a student, once having taken in an available design, multimodal texts of any/every kind, and made meaning from it, is changed forever more.

The experience "leaves the designer Redesigned (capitalization in text)" (p. 12). Figure 2.3 above illustrates my interpretation of Cope and Kalantzis' design cycle. In the act of considering the design, the student makes personal meaning from it, forever changing his own outlook. The text, too, is now transformed in the student's interpretation of it. The student becomes a designer, s/he is *Designing* a new text. Modified in the mind of the student the text is now *The Redesigned*, a product of the available design and the student's cognitive mind. Table 2.1 provides more specific details of the design cycle.

Table 2.1: *Design Cycle (Cope & Kalantzis, 2009, p. 12)*

Design Component	Designs of Meaning
Available Designs	Found and findable texts from which meaning can be made: culture, context, and purpose-specific patterns and conventions.
Designing	The act of meaning: work performed on/with Available Designs in representing the world or others' representations of it, to oneself or others.
The Redesigned	The world transformed, in the form of new Available Designs, or the meaning designer who, through the very act of Designing, has transformed themselves (learning).

The design process can provide a useful explanation of an individual's iterative designing process, and it can also be useful in thinking about a collective iterative design process. The redesigning of an available design, the interpreting and reapplication of the author's original work, yields the next generation of thinking about the topic at hand. It is applying a never-before-considered adaptation of the work. Collective redesigning within the scientific community is demonstrated with a brief walk through the development of cell theory (Table 2.2).

These few entries highlight key steps of the design process. These students of the sciences—albeit professional scientists—examined the designs available to them, and redesigned them to meet a need or to better describe a natural phenomenon. For brevity I have chosen to stop at mitosis, the topic of the student work in this TAR.

Table 2.2: *Contributing Design/Redesign Steps in the Construction of Biological Cell Theory*

Early Greek philosophers don't experiment.		
~450 BC	Empedocles (Greek) (founded the science of medicine)	Taught that all matter was composed of *four elements* earth, air, fire, and water.
Microscope is invented.		
1590 AD	Dutch lens grinders	Produce the first compound microscope.
Hooke observes "cells."		
1665	Robert Hooke (English)	Hooke observes cork slices using a microscope he designs, names the tiny compartments, *cellulae*.
van Leeuwenhoek observes "*animicules*."		
1683	Anton van Leeuwenhoek (Dutch)	- Develops a new microscope from Hooke's design. - Studies liquids. Sees single-celled, animal-like organisms in water drop, names them *animalcules*.
Scientists define cell components.		
1802	Franz Bauer (Czech)	Describes the cell nucleus.
1831	Robert Brown (Scottish)	Names cell nucleus.
All organisms are "made of cells."		(Scientists collaborate/ communicate findings across Europe.)
1838	Mathias Schleiden (German)	Concludes all plants are composed of cells.
1839	Theodor Schwann (German)	Reports that all animal tissues also consist of cells.
Cells are seen to conduct "mitosis" to replicate and pass along chromosomes.		
1852	Robert Remak (German)	Studies cell division and writes *omnis cellula e cellula*, "cells come from preexisting cells."
1866	Gregor Mendel (Austrian)	Studies pea plant and finds evidence for two contributing *alleles*, one per parental contribution.
1879	Walter Flemming (German)	Noted that chromosomes replicate and split longitudinally. Names the process "mitosis."

Scientific application of the design process in this regard and in many others has truly changed the world. I suggest this science writer's workshop as a parallel process for our young scientists as they invest in their own collective, iterative design process and more fully participate in the TAL and the scientific concepts as a result.

Language learning is social and involves collaborative dialogue.

A final characteristic of a sociocultural approach to learning is that it is a collaborative process. Social interactions are implicit in the preceding discussions (about sociocultural contexts, active meaning-making, and mediation). Science teachers can plan for teacher-led discussions and for peer-peer discussions about the content.

A goal for science teachers would be for students to engage in discussions in which they work collaboratively on problems related to both the content and to the language forms that scientists might use (vocabulary, syntax, and organizational structures). In the field of language learning this has been called *collaborative dialogue* (CD). Collaborative dialogue, as explained in Swain (2000), "is dialogue that constructs linguistic knowledge. . . language use mediating language learning." In Vygotskian terms, CD is "cognitive activity and social activity" (p. 97), a sociocognitive endeavor. Swain, Kinnear, and Steinman (2011, p. 41) further clarify CD as ". . . building on what each interlocutor has said to create new knowledge and solve problems." The key to CD is the co-construction of new meaning.

Research suggests two rationales supporting the use of collaborative dialogue in high school science classes, especially when teachers are attempting to integrate language and content objectives. First, learners have the opportunity to self-regulate, to recognize and repair their own mistakes and misunderstandings. When learners speak with one another they listen to themselves and "self-repair their errors, . . . benefiting their language development" (Lyster, 2007, p. 116). Swain and Lapkin (1998) cite that, "learning does not happen outside of performance; it occurs in performance" (p. 321). The intentional application of collaborative dialogue in the co-construction of meaning will provide implicit learning opportunities.

Second, pairs and small groups of students benefit from teaching one another the concepts that they themselves understand. Storch's (2002) work with various collaborative pairs demonstrated that "the act of teaching or explaining to others may help L2 learners construct a more coherent and clearer representation of their own L2 knowledge" (p.122). She states that, "language use facilitated negotiations over language choice," and that "participants were actively involved via requests, explanations, and repetitions of suggestions" (p.148). To internalize their development of the critical communication skills of speaking, reading, and writing, learners require frequent, cognitive use (thoughtful application) of the desired expressive form.

Teachers need to think about how to group students to encourage productive conversations. For example, Storch (2002) identified pairs of students according to their roles in the collaborative conversations. In this study, Storch noted that the more interactive dyadic pairs were comprised of an *Expert/Novice* pairing or a *Collaborative pair*. Expert/Novice pairings involved an expert learner who "actively encourages [the novice] to participate in the task" (p.129). Further, Storch's research found that "the graduated and contingent nature of the assistance provided by the expert acted as scaffolding for the less able participant" (p.121). Here, the role of the expert as conversation leader is more critical than the knowledge they bring into the discussion. Collaborative pairs by definition were operating with both high equality and high mutuality, e.g. the pair were equally engaged in the conversation with inputs mutually appreciated in the interaction.

Kimmerle et al. (2017) conducted a study centered around the collaborative development of dialogue. Their continuum is broken into five stages of development starting with sharing and comparing of knowledge and culminating with agreement and application of new meaning (Kimmerle et al., 2017). This work applies directly to my investigation of patterns in collaboration and the written products of collaboration.

The five-stage schema (Table 2.3) is divided by specific features of knowledge construction. Kimmerle et al. found that the free-flowing, liquid nature of CD dictates that these stages, steps, or delineations are challenging to precisely isolate and examine. Further, "the full five-stages model is not necessarily required to describe the individual sequences of collaboration" (p. 199). Kimmerle et al. found that "only a small number of contributions could be assigned to the stages two through five" (p. 199). In appreciation of their own observations and my own teacher time limitations my study intends to focus on the three more clearly defined stages: stages one, three, and five of Kimmerle et al.'s grounded theory-based, five-stage co-construction of knowledge.

Table 2.3: *Stages of collaboration (Kimmerle et al., 2017).*

Stage	Title	Contents
Stage 1	Sharing and comparing of knowledge (Kimmerle et al., 2017, p. 199)	Includes the stating observations and opinions, asking and answering questions, as well as defining and describing a problem.
Stage 2	Discovery and exploration of inconsistency among concepts or statements	Comprises identifying areas of disagreement and clarifying the extent of disagreement.
Stage 3	Negotiation of meaning and co-construction of knowledge	Includes clarifying the meaning of terms and identifying the areas of agreement.
Stage 4	Testing and modification of proposed synthesis	Testing an achieved conclusion against existing cognitive schemas and personal experiences.
Stage 5	Agreement and application of new meaning	Comprised of summarizing agreements and metacognitive statements that illustrate that people's ways of thinking have changed.

Language and literacy as mediational tools, even in a science class.

Language is a psychological tool used to facilitate scientific efforts in every way. It is how scientists discuss and explain our discoveries and wonderings. In the science classroom students periodically experience what educators call "a-ha!" moments of personal realization or discovery. Vygotsky (1978) says these moments, "when practical and abstract intelligence converge," represent "the most significant moment(s) in the course of intellectual development" (p. 24). These moments occur through the cognitive processing of language and other mediating tools and can be expressed spontaneously through the use of language. In the gap between colloquial English and targeted TAL lies the science writer's workshop, a framework for language mediation, with the potential to be applied in a number of unique cultural, social, and academic contexts.

It could be said that science consists of recording one's thoughts of how the universe works for others to ponder and improve upon. In his research, Vygotsky (1978) considered that "[language] acts as an instrument of psychological activity in a manner analogous to the role of a tool in labor" (p. 52). Using language as a *cognitive tool*, scientists are able to execute our thinking, planning, and questioning as those scientific thoughts are investigated (measured, tested, analyzed). Subsequently, using language as a *tool for communication*, scientific findings are presented to the world at large (documented and reported). This also describes how young scientists in a science course can use language as a meaning-making tool.

Reading and revising one's previous work causes a person to revisit their perceptions on the matter in their new state of mind, under their present prescient perspective, their current schema, their worldview. Putting thoughts to paper requires accessing extant designs and applying (Redesigning) them to explain our abstract wonderings. These are activities science students engage in daily with intent to better explain themselves. Smagorinsky (2013) stated that such exploratory language use "creates opportunities for writing that is not graded," that students might, "write informally . . . as ways of working through ideas" (p.194). The works of Vygotsky and Smagorinsky support the writer's workshop because the recursive, exploratory, step-wise nature of their scientific writing gives students opportunities to produce and self-assess their ungraded writings. Wells (2007) expands on Vygotsky stating that semiotic mediation means, in the dialogic sense,

> . . . the use of language as a sign—an instrument of psychological activity in a manner analogous to a tool in labor (Vygotsky, 1978)—which functions as a means of social or intrapersonal discourse (p. 245).

In an inquiry-based academic sense, mediation employs dialogue, gestures, and symbols to stimulate a student's deeper thought in lieu of explicitly teaching the answers or strictly testable content to passive students. Tools of mediation, "utterances, intonations, gestures, symbols, and context are used to communicate wants and needs while achieving the necessary intersubjectivity to sustain conversation" (Wells, 2007, p. 253). Mediating the gap between comprehension of the abstract concept and the concrete activity itself engages the development of a student's cognitive abilities and processes for later use in solving other scientific problems or answering other academic questions. Wells (2007) speaks of the multimodal tools of mediation in terms of the co-construction of knowledge:

> . . . the development of children's understanding of their world . . . needs to be understood in terms of a co-construction of knowledge through jointly conducted activities that are mediated by artifacts of various kinds, of which dialogue is the most powerful. (p. 247)

Johnston (2012) reminds us that "time for extended dialogic conversation is critical" (p. 65). Wells (2007) asserts that once sufficient intersubjectivity, has been achieved, "[the student] is able to communicate information, both asking for information from others and, still later, telling others what they do not already know." This higher level of comprehension and understanding takes time to develop a linguistic meaning potential that will enable a student to truly engage in a technical, academic dialogue. "Fortunately," says Wells, "there is more to interaction than just the words spoken" (p. 254). Lantolf and Thorne (2007) and others have brought forward the idea that applying culturally responsive/culturally situated tools and methods help to mediate learning by building helpful context in my science classroom.

Literacy has, quite literally, changed the physical world. In his writings Vygotsky discussed literacy in terms of mediation by symbolic artifacts, "the specifically [human] capacity for language enables humans to plan a solution to a problem prior to its execution" (Vygotsky, 1978, p. 28). Lantolf and Thorne (2007) explain the value of "the human capacity to use symbols as tools—not to control the physical environment but to mediate their own psychological activity" (p. 201). This capacity to use symbols as languaging tools has brought about the Anthropocene period (Stromberg, 2013), the industrious human-dominated time in world history. Literacy allows ideas of every kind to be passed beyond their originators, defeating the boundaries of time and geographic separation.

> Language is the most pervasive and powerful cultural artifact that humans possess to mediate their connection to the world, to each other, and to themselves. (Lantolf & Thorne, 2007, pp. 201-202)

To extend from Lantolf and Thorne (2007) then, the capacity for languaging embeds within it the opportunity for humans to step outside of their here-and-now and plan for a future event, or to communicate with a distant receiver—distant geographically or temporally—about a significant entity or event that does not exist in the sender's physical present. Because my parents were literate, I am able to hold in my hands written messages transmitted to me from the past. When our Yup'ik students dance the manaq dance (*manaqyuurak*: the ice fishing dance) they are able to tell a story with as much detail as their great-grandparents told it generations ago.

Language works as a mediational tool in science as well. When a science student experiences a scientific event they imagine the concepts and attempt to reconcile the new concepts in their minds. When explaining these concepts, they do so in terms of what they know, they connect the new learning to components of their worldview. After discussing the concepts with peers, students may have made more connections and have a deeper understanding of the concepts. In future revisions the student may be able to apply more useful symbology (analogy, gesture, graphic, mathematic, etc.) or TAL to more accurately explain concepts to their peers and to others. The ability to write logical arguments based on substantive claims, sound reasoning, and relevant evidence is a cornerstone of the writing standards (State of Alaska Literacy standards, 2012, p. 2).

Literacy has been seen through the narrow lens of language since we began to develop reading and writing assessment in schools. Those definitions are standards of the *old literacy*. When The New London Group met in 1969 the world already had many interpretations of literacy, but writing and speaking was seen as the key. Their more modern definitions, the *new literacies* (Cope & Kalantzis, 2009, p.12), symbols and drawing, gesture and interpretive dance have been with us for millennia. Each is able to transfer meaningful information and stimulate meaning-making beyond or differently than language alone, but language remains an essential mediational tool in science classrooms.

Disciplinary literacy: Definitions and rationale.

In our fast moving, high risk world researchers find common ground in the claim that disciplinary literacy must be explicitly taught in schools. Literacy researchers encourage science teachers to focus on disciplinary literacy, and I found that these two definitions of disciplinary learning are particularly useful to science teachers:

> Disciplinary literacy practices are cultural constructions, and many of those practices are not learned simply by observation. (Rainey and Moje, 2012, p. 74)

> A discipline-based model of literacy instruction is needed to prepare critical thinkers who are capable of comprehending and critiquing the materials they read. (Fang & Coatoam, 2013, p. 628)

In short, disciplinary literacy integrates academic language usage/comprehension with the study of scientific content by engaging students in tasks that are familiar to professional scientists. *Disciplinary literacy* "intends to develop students' ability to engage in social, semiotic, and cognitive practices consistent with those used by content experts" (Fang & Coatoam, 2013, p. 628).

Disciplinary literacy requires the development of particular thinking skills and processes. First, the skills of observation, inference, measurement, and communication are key scientific skills related to disciplinary literacy because "scientists must give talks, write papers and proposals, communicate with a variety of audiences, and educate others" (Feliú-Mójer, 2015, NP). Scientific communication is done globally using peer-reviewed professional journals, scientific articles. The publishing of one's scientific exploits leads to critical, public analysis of their experimental claims/results. As a scientist comprehends and critically analyzes their own work and the work of others, they demonstrate disciplinary literacy. Critical thinking and data analysis are key features of disciplinary literacy. In their discussion of reading, writing, and thinking across disciplines Rainey and Moje (2012) disclose that "many indicators suggest," that educators are "failing to provide all students with strong literacy [critical thinking] instruction that will carry them through high school and beyond" (p.72).

I agree with the multiple researchers who assert that students in a critically thinking society require critical literacy education within disciplinary instruction (Fang & Coatoam, 2013; Feliú-Mójer, 2015; Rainey & Moje, 2012; Zwiers & Crawford, 2011). Zwiers and Crawford (2011) state that "an educated and productive person in today's world must be able to evaluate the facts and *use* them for meaningful problem solving" (p. 7). In their emphatic plea for reform in disciplinary literacy education Rainey and Moje (2012) explicitly state that, "it is critical for the improvement of students' academic literacy development and overall learning that *all* *teachers and literacy researchers* attend to the teaching of disciplinary literacy in every subject area" [*emphasis mine*] (p. 73).

To date the field of disciplinary literacy investigation has been neglected and "there has been little scientific research into the effectiveness of disciplinary literacy instruction" (Shanahan & Shanahan, 2012, p. 14). The primary rationale for this project is to investigate the writer's workshop, a content literacy strategy, as a method to teach middle school students how to process information critically, as scientists. As scientific thinkers, students are able to interact with their world analytically. They are more able to learn lessons from the past and critically consider the changes needed to move society forward. Without the needed deep disciplinary literacy education academia may no longer be producing informed citizens. Evolutionary science shows that without critical (rational) thought *Homo sapiens* are essentially defenseless in nature and cannot advance their society. Mentoring students' critical thinking skills is the "so what" behind my work with village elders, students, and academics to design this investigation.

Integrating science content and scientific writing: Counterbalanced instruction.

Lyster (2007) encourages educators to adopt a counterbalanced approach "that emphasizes a flexible and relatively balanced integration of content-based and [language-focused] instructional options" (p. 136). An example of language tools counter balancing content instruction/ knowledge is the teaching of scientific roots and affixes—by using a descriptive data table or an appropriate mnemonic of some sort—to improve understanding of the technical facts of scientific content. As a result, the use of one (TAL) to deepen the understanding of the other (content instruction). In my study, learning scientific content is counterbalanced by learning to use the appropriate TAL within the context of a writing task—writing a summary of the processes of cellular reproduction. Through the science writer's workshop, counterbalancing intentionally inserts languaging skill activities into content instruction in a complementary way.

Numerous authors have written of the collegial finger-pointing between who should, who must, and who will teach disciplinary literacy skills. There is however, no avoiding the fact that "teaching those words and the ways that scientists use them should be a part of the science curriculum" (Snow, 2010, p. 451) because there is nowhere else that students will learn to interpret these symbols and concepts. It is recognized that "literacy practices must be explicitly taught, just as we teach other skills" (Rainey & Moje, 2012, p. 85), and that "students need to learn to engage in extended conversation" (Zwiers & Crawford, 2011, p. 26). As content teachers we must acknowledge that readers in each discipline read through a different process and for different reasons (Moje, 2007; Shanahan & Shanahan, 2008).

Scientific reading/writing is a disciplinary literacy. According to Rainey and Moje (2012), it is a set of "shared ways of reading, writing, thinking, and reasoning within academic fields" (p. 73). As learners first analyze their own writing and synthesize the writings of others they need guidance. They require instruction in disciplinary literacy skills that will add to content instruction. To maximize content instruction, useful language instruction/interaction must be folded into content instruction in a complementary fashion. This research examines the science writer's workshop as a useful strategy for the science teacher to better incorporate disciplinary literacy analysis skills into their science curriculum.

Scientific writing is unlike the literary writing our middle school and high school students experience and the format is uncommon outside of explicit scientific works. The addition of unfamiliar TAL can make scientific writing hard to follow. That means that every word must "carry its weight" (Tobin, 2003). Tobin also remarks that "using half the words makes the manuscript twice as good, only it takes twice as long to write" (p. 1048). This fact alone, the need to write, read, and revise is off-putting for many students. Scientific report writing is further complicated because its format can be " . . . audience, topic, discipline, and [research]" specific as explained by Burke (2009, pp. 128). Rainey and Moje (2012) point out that scientific writing:

> . . . stands in contrast with the disciplinary literacy practices of [other disciplines] and that, . . . science teachers' intentional discipline specific instruction begins to help students to read, write, and think in ways that are aligned with experts in the field. (p. 74)

Scientific writing follows particular conventions in terms of organization that are different from other disciplines (Burke, 2009; Tobin 2003) using headings, subheadings, and graphic analysis tools to guide the way as are text books and this research paper. It follows a process of discovery from introduction and hypothesis, to materials and methods, to experimental results and data analysis. The report or paper ends with a discussion of results, conclusions, and implications (Burke 2009). When scientific writing isn't explicitly taught the format can be challenging to master for both experienced and novice writers. When the complexity of the scientific format is added to comprehension of complex content, many students suffer under the load. Rainey and Moje (2012) support the idea that secondary school students may struggle because "disciplinary differences may be contributing to the literacy challenges," and that they require more "discipline-specific literacy teaching" (pp. 76-77) to really be proficient in every subject.

In Tobin's analysis of three pivotal scientific articles explaining the structure of DNA, Tobin (2003) states that the "three cardinal qualities of good scientific writing are to be: brief, clear, and simple" (p. 1048). Watson and Crick's clear and simple scientific writing about their discovery of the double-helix layout of the DNA molecule may be the reason we don't hear of their colleagues Franklin or Wilkins who published two separate, extremely technical articles about their own DNA discoveries in the same edition of *Nature*.

Brevity is valued and explanations should be brief, yet as explicit as necessary. Active voice is preferred in scientific writing for its directness and brevity and yet passive voice is valuable when "the atoms were excited by the heat" (Shanahan, 2017, p. 31). Nouns derived from verbs are nominalized (adding the affix, -tion to "evaporate"). Nominalizations appear frequently in scientific writing to descriptively name processes using technical vocabulary "but abstract nominalizations should be avoided" (Williams, 1989, p. 36). Conversely, active writing uses strong action verbs that can be weakened by the use of these nominalizations. Measurable, testable, repeatable processes produce the objective, fact-based, stance of scientific writing and avoid broad, unsubstantiated claims. Figurative, story-style language makes scientific writing less direct and can distract the reader from the important findings.

To maximize clarity, "scientists use precise technical language to most efficiently communicate with one another" (Rainey & Moje, 2012, p. 74). Scientific writing includes specific words that infer specific processes not used outside of science, some are specific even among certain scientific disciplines. This writing can be challenging for students without a background in the construction and usage of scientific vocabulary. The Shanahan's work (Shanahan, 2017; Shanahan & Shanahan, 2012) cites many authors in their analysis of scientific writing. They describe this writing as noun-centric and densely packed with nominalizations and high frequency technical terminology—morphemes like chem, electro, endo, hydro, -oid, scope, and others. These components when combined with complex phrasing passes along a very specific set of meanings that is exclusive to scientific writing. Shanahan and Shanahan (2012) conclude that the most used scientific prefixes commonly appear in noun-rich texts "among a mélange of mathematical equations, graphics, and prose" used to "predict future reactions under similar conditions" (p. 14). As students interpret this dense, specialized TAL they may need to apply more interactive, low-risk activities using multimodal processes and methods as they attempt to unwrap the complex technical dialogue.

Participants in this study and all students of science, "are expected to use specialized literacy skills, strategies, and practices to engage in [scientific] disciplinary learning and socialization" (Fang & Coatoam, 2013, p. 628). Mastery of scientific vocabulary and writing processes are critical for students to communicate their discoveries and their wonderings with one another as they explain their critical scientific content. As Greek and Latin connections and other scientific roots and affixes incidentally appear in our class sessions we log them for future reference. As students become familiar with these language tools they are able to access more scientific terms and words from other genre on their own. In addition, more intentional reading, writing, and revising is necessary in these TAL-rich, writing practices. Shanahan and Shanahan (2012) explain that students need to, "summarize what they are reading and ask themselves questions about the information in the text." That deeper focus on what a text says, "would benefit their learning" (p. 15). These are the practices of this science writer's workshop.

Designing the Science Writer's Workshop

The science writer's workshop is a writing process strategy linking the roots and complexities of scientific language into the curricular content. It is intended to give students low-risk opportunities to improve their writing/TAL literacy collaboratively and on their own terms. The collaborative, dialogic focus of this study explores the benefits of balancing integrated language objectives with content objectives in students' daily science-related activities.

The science writer's workshop concept is based on the description of a writing workshop in a language arts setting by Morris (2012) and various support tools of the North Star of Texas Writing Project (www.nwp.org), specifically the professional development advice of Patterson and Wickstrom (2017). I am striving to "see more confidence, more fluency, more enthusiastic engagement, more proficiency across multiple genres, and more critical thinking" (Patterson & Wickstrom, 2017, p. 5) in my students by conducting a more collaborative, less scripted science writer's workshop. I am defining a science writer's workshop as an opportunity for secondary science students to exercise their scientific thinking, exercise their TAL, and exercise their writing processes under the guidance of one another and myself over a sustained period of low-risk writing and revising practice. I adapted the writer's workshop recommendations of Morris (2012) for this first-time writing project, specifically focusing on

- sustained daily writing practice,
- co-constructively playing with TAL,
- modeling what writers do in scientific writing,
- guiding students through the writing process (focusing on the process, not the product) and,
- publishing for a real audience. (p. 1)

In this science writer's workshop, the topic is mitosis, asexual cellular reproduction. The intent of the science writer's workshop is to achieve improved TALA through deepened cognitive engagement with the TAL and repetition of it through a recursive writing and revising cycle. The reconsideration of different writing partners' written and spoken perspectives and subsequent discussion of those perspectives is intended to build a deeper understanding of individual student's TAL. The final outcome expectation is 1) a more comfortable use of TAL and 2) the production of strong (well supported and technically accurate) written scientific summaries.

The use of a science writer's workshop to improve the TALA of EB science students will build upon the research in Table 2.4 enabling students to engage in TAL in methods not typically invoked in a science classroom.

Table 2.4: *Principles and Supporting Research for the Science Writer's Workshop*

Principle	Supporting Research	Features of Science Writer's Workshop
Science learning happens in a sociocultural context.	Casher and Stotler (2015); Cope and Kalantzis (2009); Dyson (2015); Mahn (2012); Martin (2008); New London Group (1996); Smagorinsky (2013); Vygotsky (1978); Wilson (2008),	Invite students to use prior knowledge of science/ TAL and make connections to their personal/ social/ cultural funds of knowledge by engaging in low-risk, conversational, co-constructive writing activities.
Science learners are active meaning-makers and designers.	Kalantzis and Cope (2008); New London Group (1996); Rosenblatt (1978); Smagorinsky (2013)	Include writing tasks/assignments that require students to learn content and to integrate scientific content and Technical Academic Language, to design/compose meaningful messages, and to produce written products.
Language learning in science classrooms is social and involves collaborative dialogue.	Kimmerle et al. (2017); Lyster (2007); Swain (2000); Storch (2002); Swain, Kinnear, and Steinmann (2011); Swain and Lapkin (1998)	Provide time and support for large and small group discussions about the tasks.
Language and literacy are mediational tools, even in science classrooms.	Cope and Kalantzis (2009); Lantolf and Thorne (2007; New London Group (1996); Smagorinsky (2013); Vygotsky (1978); Wells (2007)	Provides for frequent use of critical literacy skills, integrates content and language learning through multiple opportunities for reading, talking about, and writing about the target concepts through the use of TAL.

The science writer's workshop is a step-wise (stage-by-stage) process that begins with large group instruction and the modeling of co-constructive activity in the relative comfort of a full class discussion. The workshop proceeds through a repeated process of writing, sharing, and co-constructive revising of students' writing in progressively smaller groups, stage-by-stage, until students are paired in dyads for their final drafts. The final stage of the science writer's workshop is expected to be an informal presentation of student work in the science classroom and informal publication at school.

Given the depth of data and analysis resources of Kimmerle and colleagues (2017)—hundreds of evaluated samples and a staff of analysts—I realized that precise isolation of the nuanced details in my data set would be challenging on my own and within my short reaction window. In the brief, in-class collaboration observation window I would be more able to identify students' various stages of collaboration and assess their work as they co-construct their summaries if I could focus on fewer, more clearly defined, developmental steps.

The stages of this science writer's workshop are derived from the collaborative dialogue research of Kimmerle et al. (2017). To help maintain clarity in my analysis during this research I abridged Kimmerle's five stages, grouping them into three, more obvious and well-defined stages, see Table 2.5. I combined their Stages 1 and 2, stating observations, asking/answering questions, task identification, and clarifying disagreement; combined Stages 3 and 4, clarification of terms and hypothesis testing; and left Stage 5 as did Kimmerle et al., agreement and summarizing of final statements, on its own.

Table 2.5: *TR's Operational Regrouping of Kimmerle et al.'s Five Collaborative Stages*

Stage	Title	Contents
Stage A:	Task preparation - Sharing and comparing of information	- Stating observations and opinions, asking and answering questions, defining and describing the assigned task. - Identifying areas of disagreement and clarifying the disagreement.
Stage B:	Negotiation of meaning and co-construction of knowledge	- Clarifying the meaning of terms and identifying the areas of agreement. - Testing hypotheses against prior knowledge and personal experiences.
Stage C:	Summarizing - Agreement and application of new meaning	- Summarizing agreements and metacognitive statements that illustrate that people's ways of thinking have changed.

Conclusion

The significant gap between the writing processes and TAL usage of these Indigenous Grade 8 science students' daily language and the processes and language of collegiate science students has urged me to investigate a more useful method to integrate content learning and TALA. The work of previous researchers has drawn me to apply a different method for building literacy skills into the scientific studies of my EB students. The science writer's workshop is designed to help students stretch themselves to fill the gap between their daily academic language and the TAL required in post-secondary education.

I have argued that a science teacher must fold in language instruction to maximize content learning and incorporate literary skills analysis into the science curriculum. The focus of this study is improvement of the students' scientific writing skills and processes. This study explores the benefits of balancing integrated language objectives with content objectives in students' daily science-related activities. It examines the possibility of deepening of students' scientific literacy through internalizing TAL by using a sustained writer's workshop activity.

In accordance with Vygotsky's ZPD the abilities of a collaborative group can exceed the combined cognitive abilities of the individual participants. The literature supports the notion that students are more capable than they are aware. When pulling toward their common goal a dyadic pair is able to collectively synthesize and accomplish more together than either could separately. The give and take interaction between students piques their individual abilities and allows them to sharpen one another's thoughts. The methods discussed here and the works of the referenced authors provide a strong basis for continued action research on the use of co-constructive dialogue for TALA in the science classroom.

In subsequent chapters I will explain and discuss this study. Chapter 3 will focus on data collection methods and procedures, Chapter 4 will provide detailed data analysis, and Chapter 5 will sum up my finding, conclusions, and implications for future research.

Chapter 3: Research Methodology

This research project explores the co-construction of technical, academic language (TAL) in a science writing workshop. The small group-centered research plan investigated opportunities for co-construction and scientific writing during a unit on mitosis.

Research Questions and Audience

The focus of this action research was motivated by my desire to better serve the academic needs of our Yup'ik science students in Mountain Village School. Though I am not a trained bilingual language teacher, I am charged with instruction of technical, academic language (TAL) among emerging bilingual (EB) learners in my middle school science classroom, who, as are many mainstream learners, are somewhat overwhelmed by the challenge. It is for their benefit that I have pursued research into a more language-based method of TAL instruction in the science classroom. Specifically: How do middle school students engage in content learning and in the use of TAL during a science writer's workshop?

Participants were eighth grade, General Science II, students studying the process of mitosis, asexual body cell reproduction.

Study Design

The study is aligned with Mills' goals for teacher action research (TAR), of gaining insights, effecting positive changes in the school environment, and improving student learning outcomes (Mills, 2018, p. 17-18). TAR invokes a practice of systematic inquiry focusing on increasing the predictability and decreasing the barriers to learning in the classroom.

Teacher action research.

Literacy-centered, qualitative teacher action research (TAR) is not the traditional method of "doing science" in the science classroom. It is however an excellent method by which to document, analyze, and evaluate, classroom processes. Freire (1970) gave a call to teacher action stating that "the teacher . . . while being taught also teaches . . . [and is] jointly responsible for a process in which all grow" (p. 80). Mills (2018) defines action research as "systematic inquiry conducted by teacher researchers in [their classroom] to gather information about how they teach and how their students learn" (p. 10). As such TAR is a self-imposed, reflexive analysis of my instructional practice and student performance results. The discovery process of TAR is a bit invasive and uncomfortable, yet in this uncomfortable look inside my teaching to my habits, into "my embryonic society" (Dewey, 1907, p. 32), TAR is able to reveal insights to me without imposing laboratory-like research conditions on my students.

TAR described.

A key to maximizing classroom learning is "building students' academic communication skills" (Zwiers & Crawford, 2011, p. 5). Teacher researchers must honestly assess their own strengths and weaknesses to focus on improving their classroom instruction. Putting institutional change in the hands of the practitioner and allowing themselves to be the agent for change in their classroom is the heart of TAR. TAR is unlike laboratory-style research processes because it is done by teachers, for teachers, in classrooms with real learners, yet there are many similarities to more traditional scientific research methodologies. According to Mills (2018), TAR can be done independently, collaboratively, or as a professional learning community, and the intent is always to improve the educational experience for the learners at-hand. Mills points out that the driving force behind TAR is a teacher "committed to continued professional development" (p.16) in the classroom with their own students' best interest in mind. TAR is extra effort on the part of the educator to better meet the needs of the students in their care by bringing rational change into the classroom educational process.

Rationale for TAR.

In the seminal days of public education Dewey (1907) reminded us that "knowledge is no longer an immobile solid" (p. 40) and that "if our education is to have any meaning for life, as society transforms [academic education] must pass through [a] transformation" (p. 43). Change in our classrooms is best done by its practitioners, the teachers and students working within it. TAR is such a mechanism for change.

In his discussion of the rationale for TAR, Mills (2018, pp. 18-22) clarifies four key justifications. This TAR reinforces Dewey's observation that change comes from within the classroom.

Table 3.1, describes this TAR as an authentic resource for educational change in terms of Mills' definition.

Table 3.1: *Mills (2018) Rationale for TAR in Relation to this Research*

Rationale of TAR according to Mills	Characteristics of TAR in my research
Persuasive and authoritative. Action research is done for teachers by teachers collecting data that is of immediate concern in their classroom.	This study focused on the use of co-construction to summarize a complex life science topic, eukaryotic cellular reproduction.
Relevant. Data is collected in authentic classroom circumstances.	This study was conducted with an unfiltered group of Grade 8 learners, their true-life struggles, teen drama, power plays, sporting events, illnesses, and scheduling uncertainties.
Connects teachers to research findings. The authentic nature of real-room data collection is eye-opening and what reflective educators seek.	This study focuses on the viability of co-constructive talk in TALA and stems from research into languaging episode bases (Swain & Lapkin, 1998), dyadic interaction types (Storch, 2002), stages of collaborative development (Kimmerle et al., 2017).
Challenges the status quo of formal education. Change comes from inside teachers and their classrooms.	This study addresses an interactive method for TALA which may affect a change of educational worldview by offering thoughtful educators a different perspective, stimulating further TAR across global EB communities.

This action research project is persuasive and authoritative because it has been conducted in a real classroom over three weeks. The events were subject to all of the stressors of the spring semester: state proficiency testing, EXCEL Camps (one to two week, off-site student immersion experiences), village and family tragedies, weather holds: stranded basketball students and unplanned mid-winter weather delays in school-wide field excursions, basketball tournaments, and more. Though my classroom experience is unique to my community, the microcosm of the science classroom is familiar to science teachers everywhere. This research is relevant to all TALA facilitators because learners in general struggle with the same physiological, personal, and social needs. Knowing the language of the classroom is one of those needs and approaching the mastery of TAL from the perspective of language acquisition in the science classroom is an uncommon approach.

TAR is empowering, allowing me as teacher-researcher the agency to be the change I want to see in my classroom and in turn in the world. Freire (1970) gave a call to teacher action stating that "the teacher is no longer merely the-one-who-teaches, but who in turn *while being taught also teaches* . . . jointly responsible for a process in which all grow" [*emphasis mine*] (p. 80). In calling for critical engagement in the process of education reform he further posits that, "dialoguers engage in critical thinking . . . thinking which does not separate itself from [transformative] action, but constantly immerses itself in temporality without fear of the risk involved" (p. 92). Idly standing by as a "bank-clerk educator" (p. 76) is unconscionable. TAR is a mandate for disruption of the status quo in the classroom and the realizations of this study have already made an impact on my practice.

Process of TAR.

Mills (2018) explains the process of a recursive TAR procedure, a self-evaluation process he's dubbed the *dialectic action research spiral*. Figure 3.1 shows that the interwoven process moves through choosing a research focus (topic of concern), developing a plan of action (research plan), data collection, and data analysis. The nature of the process is shown in Figure

3.1 as clockwise succession of steps feeding into one another as needed. It is also very reasonable for the researcher to loop back to any given step to reevaluate it in light of new information or in light of an emergent realization.

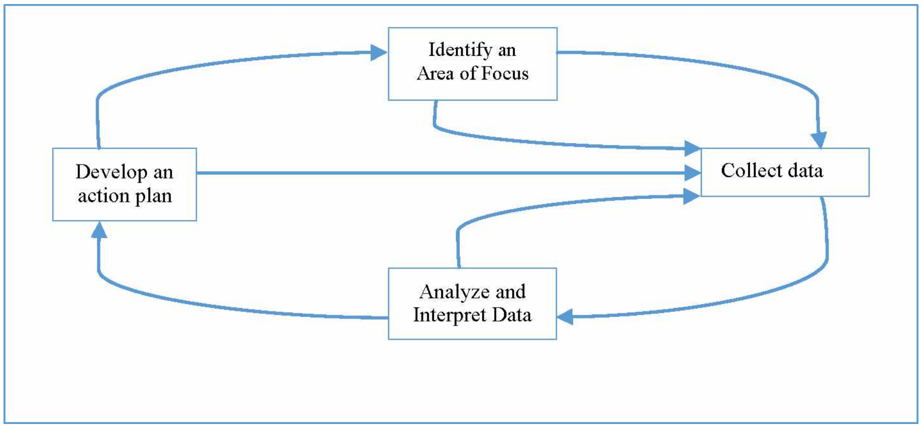


Figure 3.1: Adapted from Mills' dialectic action research spiral (p. 26).

In deference to Mills' dialectic action research spiral my TAR-based research process generally progressed as follows:

Identify an area of focus. When I began teaching science while still using the more traditional style of science instruction I found my student populations, especially EB learners, struggled with appropriate use of TAL. My earliest TAR was focused on the improvement of my instructional practice in teaching TAL to my secondary science students.

Collect data. I was a well-educated science teacher with only a limited background in language education instruction, but language was emerging as the hurdle I needed to overcome. Over a period of years, I observed different student groups in different learning communities as they were learning TAL. I noticed that more language-based processes seemed to engage students' motivation to engage with, and master the content.

Analyze and interpret the data. The process was conducted using a dynamic, recursive process that kept student needs ahead of the research and yet kept the versions of the method, co-

construction, front and center. As I applied different methods and techniques along the way, I collected more data.

Develop an action plan. In response to the data I modified lessons and collected more data. During the data collection period I developed an early form of the science writer's workshop using co-construction, an emerging methodology in my eyes at that time. Though lessons and activities were fully and thoughtfully planned, the process and results were systematically reviewed, analyzed for effectiveness, and adapted as needed to meet the fundamental student and research objectives. After a time, the science writer's workshop began to emerge from the process.

Validity of TAR in science education.

To be useful to readers, research must be trustworthy, worth the read to busy practitioners. Mills cites Guba (1981) to list four factors of trustworthiness in research (Table 3.2): credibility, transferability, dependability, and confirmability (pp. 153-154).

Table 3.2: *Validity Matrix of this TAR*

Components of validity per Mills	How validity is maintained in my research
Credibility of data resources	Through extended observations (12 sessions) and peer review of data by critical friends/colleagues.
Transferability of the research	TAL is a need in all technical instruction. Application of co-construction for TALA has value for all. All these procedures are feasible in a range of science classrooms.
Dependability of the data	The data collected are supported by routine, accurate research journals which follow my mental process during the study.
Confirmability of results	Triangulation of multi-sourced, multi-modal data allows for multiple perspectives of each session.

In this study Mills' four factors of trustworthiness have been met as follows:

Credibility. Debriefing with colleagues, the use of long-term observation, collegial feedback, language-based scientific tasks, reflexive journaling, feedback from participants, and the use of multiple data sources. The extended data collection period and critical collegial review/feedback of this collaborative synthesis research help to make the observations credible.

Transferability. Keeping the results both specifically applicable to science and broadly transferable to other classrooms make this study more applicable to educators.

Dependability. Regular research journal entries and participant feedback through periodic member checks helped to keep the learning journey intact and maintain the reliability of the study.

Confirmability. The use of multiple, redundant data sources provided opportunities to see different perspectives and conduct triangulated analysis.

Analytic Framework: Constructivist Grounded Theory

According to Charmaz (2014) constructivist grounded theory (CGT) is a data-first theory construction process that acknowledges the fleeting nature of knowledge and understanding. Line-by-line coding of dialogue, recursive evaluation of those codes, and focusing on the most affective of those threads boils down extended conversations into well-defined clusters of concentrated data. More specifically Charmaz explains that CGT is an adaptive, cyclic, theory construction process that guides the researcher as he recursively samples and analyzes dialogic data while constructing a useful hypothesis for newfound relationships and avoiding preconceived notions. Table 3.3 describes how the implementation of CGT is supported within my TAR.

Table 3.3: *Charmaz (2014) Implementation of CGT Within this TAR Analysis*

CGT procedures according to Charmaz	Implementation of CGT in my TAR
Initial coding. Comparing data with data, line by line, using gerunds to emphasize actions.	*Initial coding*. I read the data multiple times and assigned a code in the form of a gerund to each unit of text. The gerund emphasizes the actions of participants.
Focused coding/Categorizing. Comparing codes with codes heightens and clarifies the theoretical centrality of certain ideas and unexpected ideas emerge.	*Focused coding/Categorizing*. I read and evaluated the initial codes and constructs more generalized groupings that reveal larger patterns in participant's activities.
Theoretical coding. Integration of various analytical schemes "lends form to the focused codes (p. 150)" and aids in moving the analytic perspective to a more cogent, theoretical perspective.	*Theoretical coding*. My theoretical perspectives arose from coding participant activity using a variety of analytic schemes. Integration of the focused code groupings into more abstract theoretical codes brought coherence to the patterns in participant activities.
Theory building. Emerging patterns of how and why participants construct meaning are compared against further data. Theories for learner actions rise out of the data during/ after focused coding.	*Theory building*. I focused on the participants' co-construction processes while applying TAL in their writing. The theoretical connection of emergent codes and patterns within those codes became the focus of the analysis.

The process of generating and applying *initial codes*, line-by-line action-based gerund phrases to transcriptions helps to clarify the activities of the participants. Following the initial coding, *focused coding*, a recursive analysis of the initial codes, helps the analyst to "trim away the excess" (Charmaz, 2014, p. 141), clustering the action-based data into activity threads. Systematically processing the data in this way refines the action to expose "concentrated, active involvement" (p. 142) that develops a "more theoretical reach" (p. 141) within the data. Through the process of focused coding "new threads for analysis become apparent . . . perspectives come into view that you had not thought of before" (pp. 142-143).

Constructivist grounded theory explained.

Because grounded theory analysis focuses on learner actions and processes rather than preprogramed themes and structures, meaningful codes and interpretations arise out of my close relationship with the data (p. 142). In quantitative analysis the sample and analyze cycle continues until all of the unique data can be accounted for and a generalizable principle can be established. This is not the case with the theoretical sampling process of CGT (Charmaz, 2014, p. 199). The subtle difference is that in theoretical sampling, according to Glaser (1978), when the data supporting emerging patterns "reveal *no new properties* of the pattern" [*emphasis mine*] the pattern is considered to be saturated (as cited in Charmaz, 2014, p. 213). Saturation indicates that no new properties are emerging. An emergent category arises when the collective weight of the pattern property data and written analysis memos have accounted for all the salient features/actions. They may then support a theory for the relationship(s). If no theoretical relationships appear, then the sample and analyze process is not yet complete.

CGT keeps the researcher interactive and involved (grounded) in the data. Staying close to the data helps to assemble a clear picture of the processes observed through active initial coding, focused coding, memo-writing, and data sampling using the recursive, comparative analysis process. The goal is to "remain open to all theoretical directions indicated" (Charmaz, 2014, p. 114) and apply an iterative process to construct operational theories directly from the data. Rather than applying pre-existing codes to the data, grounded theorists trust that "the openness of initial coding should spark their thinking and allow new ideas to emerge" (p. 117).

In the context of my study I imagine TAR and CGT as nested processes, CGT within the data analysis/ interpretation phase of TAR (Figure 3.2). Mills' dialectic action research spiral begins with a teacher's area of focus (e.g. low levels of TALA) and the development of a research plan (e.g. evaluating the use of CD to build TALA) and collection of student data (e.g. recorded dialogic interactions and written artifacts applying TAL). CGT's data analysis cycle is the recursive analysis, interpretation, and action plan development process of TAR. Observational data are coded for learner actions (initial coding) and the salient data points are coded again one or more times in search of larger patterns (focused coding). The writing of thoughtful, data-based memos throughout the coding process provide comparisons between what has been observed and what is being observed. These ongoing comparisons (constant comparatives) between the emerging focused or theoretical codes and the codes already generated are the seeds of theory building. The process of noticing new actions from new perspectives and considering new questions within the data set slowly, iteratively, saturates the emerging categories.

For simplicity, Figure 3.2 seems to follow a systematic, clockwise process that is always looking ahead. The reality of the process is that the researcher continuously reflects on the previous step while conducting the present step, sometimes taking a step back to reconsider an emergent perspective or new data before moving ahead once again.

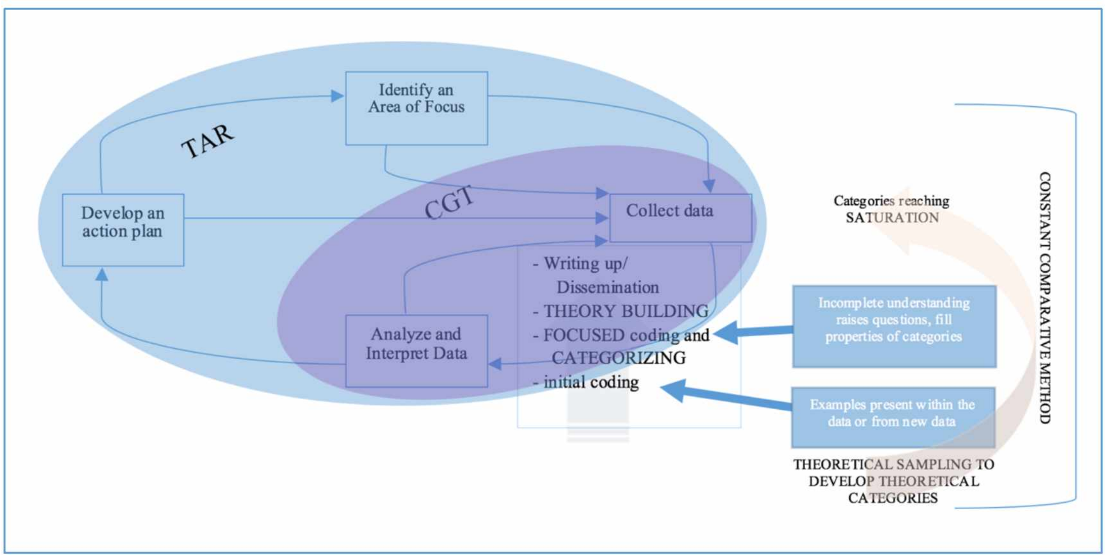


Figure 3.2: Nested CGT within TAR. Adapted from Mills' dialectic action research spiral (p. 26), and Charmaz' grounded theory cycle (p. 18).

Classroom Setting

The selected participants were reasonably successful in the classroom, generally attentive and hardworking students with positive, helpful, and inquisitive attitudes. Students are self-distributed around tables one, two, and three, as shown in Figure 3.3, habitually choosing seats with a view of the SMART Board. During Step D, Small-group Revising and Editing work, participants were typically seated as listed in Table 3.4.

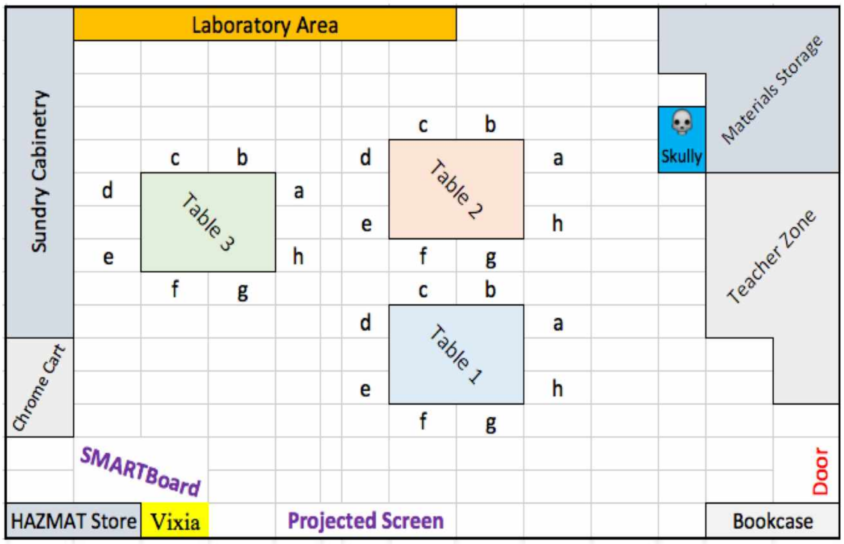


Figure 3.3: Science classroom layout.

Table 3.4: *Participant's Typical Seating Arrangement*

Participant	Table/Seat	Small-group
Brie	3/h	n/a
Cathy	3/e	n/a
Harry	1/b (c)	C
Helen	2/a	A
Matt	1/d (e)	C
Stu12	1/a (h)	C
Tommie	2/c	A

Context of the Research

The secondary school population was 100 % Alaska Native and lifetime bush residents, all testing "below proficient" in English language literacy on statewide standardized assessments. The community of less than 900 citizens is bicultural and bilingual with strong ties to the subsistence lifestyle. Most families/students have declared English as their first language on registration forms and the on-campus dialect is functionally monolingual English. Few adults are fully bilingual and some elders are obligatory Yugtun speakers. Due to its small size (~200 students K12), Mountain Village School's curricula and elective options are limited. Two elective Yugtun courses are offered per semester.

Participants

Grade 8 students of Mountain Village School (MVS) in Mountain Village, Alaska, were recruited as study participant candidates and all students were equally encouraged to participate. The positive and inquiring attitudes of the 8th grade, General Science II, class showed me that they were the overwhelming best choice for this study.

Participant candidates were invited into my study at an in-class briefing in January, as we began the new life science unit and again at our parent meetings in early February. All candidates submitting parental authorization and assenting to participation were selected as participants, seven in total, in February. Students chose pseudonyms for use in the study.

All participant volunteers were in Grade 8, four females and three males. All enjoy positive teacher-student interactions and are active in intermural sports. Six of these eighth grade participants are strong or relatively strong performers who volunteer to read, participate, and interact in class daily. Five participants typically participate in the school science fair and other academic extracurricular activities. The parents of four participants are employed at the school, district office, or in city management. Two participants are a little more dependent on group interaction to find their success. All students completed the prerequisite instructional readings independently or in pairs and were able to complete the article review assignment.

Data Collection Procedures

An informational, family meeting was held after school to discuss project recruitment, benefits and liabilities. Consent forms were provided in English and explained to the children and guardians attending the parent meeting in the first week of February. An assent form was read to candidate participants. Assent/Consent forms were scanned to the authorized hard drives and originals are kept on file per UAF IRB requirements. This project has been approved by the University of Alaska-Fairbanks, IRB. Project IRBNet ID: 1157759-1 (see Appendix A).

Data collection was done in my science classroom. Student data/conversations were collected during the collaborative writing process of a routine classroom procedure, production of a topical scientific summary. The data sources for this investigation included digital audio and video recordings, students' collaborative summaries and individual summaries (students' written artifacts), teacher's observational notes and research journal as delineated in Table 3.5.

Table 3.5: *Relevant Data Sources*

Research Question	Relevant Data Sources				
	Audio recording of group dialogue	Video recording of group dialogue	Students' collaboratively written summaries	Students' individual summaries	Teacher observational notes/journal
How do middle school students engage in content learning and in the use of TAL during a science writer's workshop?	x	x	x	x	x

Science Writer's Workshop

I chose an informal science writer's workshop as the in-class co-construction process. In the context of this research the science writer's workshop is small group-centered, TALA instruction method intended to give students experience with TAL while practicing the art/skill of thinking through a scientific process as scientists. In relation to the overall curriculum this "Mitosis" science writer's workshop topic and the enrichment topic "Comparison of Mitosis and

Meiosis," followed a study of the structure and function of eukaryotic cells (plant and animal cells) and preceded a more detailed study of genetic variety and DNA.

The concept.

The science writer's workshop is intended to comfortably draw all learners into their abilities as critical thinkers, resource synthesizers, and co-constructors of meaning while building their comfort with the TAL. The science writer's workshop activities followed two weeks of more traditional instructional class sessions on the topic of mitosis.

Stages of the Science Writer's Workshop.

The step-wise process included individual, whole group, and small-group drafting and revising stages as students wrote explanations of mitosis and meiosis. The science writer's workshop process involved pre-workshop instruction and five stages of the workshop proper:

- Pre-workshop Instruction: Learning the Concept/ Prewriting
- Stage A: Individual & Whole Group Drafting
- Stage B: Small Group Reflecting & Evaluating
- Stage C: Small Group Revising
- Stage D: Small Group Revising & Editing
- Stage E: Extension: Small Group Drafting, Revising, and Editing

Throughout this investigation these steps follow the design, designing, redesign process brought forward in Cope and Kalantzis' (2009). The notes from readings provide the available designs for language that explains the scientific concepts, collaboration presents the designing opportunity, and the final written and spoken performances are the redesigned (reinterpreted) original concepts.

The list below shows the characteristics of the workshop. These helpful writer's workshop tools and helps were adapted from Morris (2012). The science writer's workshop process flowed from class-wide group to table groups, and from table groups to dyads as we progressed from stage to stage. The plan was to divide the class into a full set of dyads, but there were complications, chronic absentees, drama, unannounced family travel, illness-related discomforts, and 's/he's my best working partner' issues. In the end we managed to lock-in two dyads, and a triad of mutually agreed upon writing analysis partners.

Our Science writer's workshop involved:

- Daily small group-based writing, discussion, revising sessions.
- Writing for an authentic purpose, a public poster publication.
- Informal, individual teacher coaching conversations as needed.
- Congratulatory moments, pats on the back for thinking it through, for helping your dyad/triad get to their goal.
- Teacher modeling provided in mini-lessons as needed.
- Presentation of final results in class, on the Great Wall of Science, and Project Keepsake to show off our work to the world (not conducted due to unforeseen events in the school community).

We made it our daily intention to focus on our writing and not so much on timelines. We wrote with intent to publish our words to the Great Wall of Science outside the classroom and to type up a formal copy to share at home. Project Keepsake was to be a smooth, typed document printed on certificate paper to be taken home to parents/ guardians. As daily sessions played out I quietly walked the room listening for people dialoguing, struggling usefully or excessively, and for extreme off-topic activity. I made myself available for those in need, on-demand. Otherwise

I circulated, attended to administrative classroom details, or feigned puttering so as not to draw attention while I sketched notes on student activities and arrangements. As we conducted our daily wrap-up routine I would make it a point to thank the class for writing like champions, for keeping their dialogue flowing, and for working to keep their small-groups on track. On two occasions when there was confusion or stage-related transition stress we took a day off from writing and conducted a lighthearted mini-lesson in a round table format to clarify our motivation and to discuss the extension topic (meiosis).

To provide tools for students to write these passages explaining the scientific concepts, I compiled a packet in which the students could draft and revise their writing (See Appendix B). The science writer's workshop packet was to contain a cover page and a single, lined page for each stage of the workshop. Each page included brief instructions at the top and a lined writing area below.

Figure 3.4 shows the top half of the Stage A, Whole Group drafting page (listed as a Group Brainstorm on early packet drafts). One of the initial tools was a list of sentence frames designed to elicit a paragraph to explain a concept, Constructing Meaning or **CM**®. The **CM**® *Explain and Describe* sentence frames (Figure 3.5) were used as a launch pad for our collaborative processes in the science writer's workshop activities.

Topical Scientific Summary Workshop - **Note-taking Sheet**

name: ____________
date: ___/____/____
period: ___________

Topic: ____________________________________

CM®-Student Flipbook paragraph type: ***(can be changed later)***

Cause & Effect Compare & Contrast Explain/Describe

Proposition/Support Sequence

Group Brainstorm:

To open: ____

____.

To expand: ____

____.

To support: ____

____.

To close: ____

____.

=======

Rewrite the class's rough paragraph here. Make any noun/verb syntax adjustments as you do.

____

____

____

Figure 3.4: Science Writer's Workshop, note-taking sheet (Stage A, Individual and Whole Group Drafting, writing page).

CM Explain "Explanatory Paragraph" template

Explain and Describe

To open	▪ ______ is best described as _______. ▪ To define _______, it is necessary to understand ________. ▪ _________ is known for _______, and is important because _______.
To explain or describe	▪ ______ is an illustration of ______. ▪ ______ is frequently referred to ______.
To support your ideas	▪ Critical attributes of ______ include ______ and ______. ▪ A defining characteristic is _______. ▪ The key components are _______ and ________.
To close	▪ An explanation of ______ provides insight into ______. ▪ A complete definition of ________, allows us to _______.

Figure 3.5: E.L. Achieve's **C**onstructing **M**eaning® "Explain and Describe" template provided sentence frames for student writing (reinterpreted excerpt from **CM**® Student Flipbook).

An overview of the science writer's workshop flow during the students' writing about mitosis follows in Table 3.6. The five workshop stages are explained in detail in Chapter 4.

Table 3.6: *Stages of the Science Writer's Workshop (Including Pre-Instruction)*

Name of Stage	Explanation of what students are doing
Pre-workshop Instruction Learning the Concept/ Prewriting	- *Discuss* animated, Amoeba Sisters mitosis video lecture. - *Define* mitosis vocabulary and cell cycle from Glencoe© text book. - *Discuss* asexual reproduction from Glencoe© text book. - *Discuss* the cell cycle images from Glencoe© text book. - *Sketch* mitosis process steps from Newsela® mitosis article (Lexile-level aligned). - *Construct* a tactile mitosis mnemonic 'wheel.' - *Observe* and *sketch* viewed images of prepared onion root tip slides.
Stage A Individual and Whole Group Drafting	I helped the whole class model co-construction. Each student used their notes (from pre-workshop instruction) to complete 4 sentence stems which served as the framework for an explanation paragraph. As each small group compared their individual sentences they chose their "favorite" sentence to share with the class. The whole class decided on 8 sentences that fully explained the concept of "mitosis." I wrote those eight sentences on the SMARTBoard.
Stage B Small Group Reflecting and Evaluating	Students were instructed to work as small groups to review and evaluate the eight sentences from the previous stage.
Stage C Small Group Revising	Students used their own notes and the eight sentences created by the group. The task was to use those resources to work in small groups to revise those sentences to create individual explanations. These conversations were recorded to capture how they talked about their decisions about what to write.
Stage D Small Group Revising and Editing	Students were to collaborate in their small groups to create a common paragraph. These conversations were recorded. Although the intent was for students to collaborate to produce one paragraph jointly, each person wrote an individual version in their notes.
Stage E Extension: Small Group Drafting, Revising, and Editing	Small groups, who had already completed their Stage D writing, collaborated on a related assignment, comparison of mitosis to meiosis.

The collaborative stages of Kimmerle et al. (2017) were incorporated within the science writer's workshop after I regrouped them in preparation for this study, Table 2.5 (previous chapter). A correlation of Kimmerle et al.'s regrouped stages and my science writer's workshop stages (Stage A, and Stages C and D) is shown in Table 3.7.

Table 3.7: *Correlation of Regrouped Stages to Science Writer's Workshop Stages*

Regrouped Stages [of Kimmerle et al.]	Science Writer's Workshop
Task Preparation - Sharing and Comparing of Information	Stage A: Individual and Whole Group Drafting
Negotiation of Meaning and Co-construction of Knowledge	Stages C and D: Small Group Revising/ Small Group Revising and Editing
Summarizing–Agreement and Application of New Meaning	Stages C and D: Small Group Revising/ Small Group Revising and Editing

Procedures

The science writer's workshop sessions are preceded by more traditional classroom instruction which included on-line reading of two student-leveled (engaging, colorful, informative, current), Newsela (*www.Newsela.com*) articles about mitosis and cell division. This website provides variations of articles a five different reading levels so that more students can have access, regardless of their reading proficiency. Various science textbooks and activities were employed as well. I modeled Stage A, Individual and Whole Group Drafting activities and collaborative writing with the whole class, during the first stage of the science writer's workshop. Following Stage A, Individual and Whole Group Drafting sessions are; Stage B, Small Group Reflecting and Evaluating; Stage C, Small Group Revising; Stage D, Small Group Revising and Editing; and Stage E, Extension: Small Group Drafting, Revising, and Editing. The collaborative summary workshop concludes with a small group poster presentation. A generalized science writer's workshop schedule is delineated in Table 3.8.

Table 3.8: *Generalized, Science Writer's Workshop Timeline*

Primary resource reading and Pre-workshop Instruction	
Lesson:	*Newsela* article reading and comprehension assessment
Class time:	2 class periods
Materials:	*Newsela* articles/quizzes Chromebook laptop computers LYSD Student internet access and LYSD Student email
Individual & Whole Group Drafting	
Lesson:	TR think-aloud and modeling summary drafting (conduct *Pretest* prior to co-construction session)
Class time:	1 to 2 class periods
Materials:	**CM**® Student Flipbook, Explain/Describe page (Figure 3.5) Science Writer's Workshop - *Notetaking Sheet* Student notes and mnemonic tools
Small Group Reflecting & Evaluating	
Lesson:	Table group feedback process from **CM**® *Explain* starter
Class time:	1 – 2 class periods
Materials:	Science Writer's Workshop - Notetaking Sheet, page 2 **CM**® Student Flipbook, Explain/Describe (optional) Student notes and mnemonic tools

Table 3.8 (continued)

Small Group Revising	
Lesson:	Collaborative pairs advance from the previous small-group feedback session
Class time:	1 to 2 class periods
Materials:	Science Writer's Workshop - Notetaking Sheet, page 3 Student notes and mnemonic tools
Small Group Revising & Editing	
Lesson:	Synthesis of individual topical summary (*Post-test #1*)
Class time:	1 to 2 class periods
Materials:	Science Writer's Workshop - Notetaking Sheet, page 4 Student notes and mnemonic tools
Extension: Small Group Drafting, Revising, and Editing	
Lesson:	Synthesis of individual topical summary (*Post-test #1*)
Class time:	1 to 2 class periods
Materials:	Science Writer's Workshop - Notetaking Sheet, page 5 Student notes and mnemonic tools

Data Collection Procedures

Student conversations during the collaborative phases of the twelve, collaborative writing sessions were collected via digital audio/video recorders. Each process step required one or more, full class period recording sessions to capture learner collaboration. Recordings for the data collection cycle were made throughout the twelve-day collaborative writing window. Given the history of learner absences, class interruptions, and unanticipated learning delays extension of this two-week collaborative synthesis window was anticipated in the process of conducting responsible instruction. Collaborative writing windows were extended at no cost to the participants. Table 3.9 shows the proposed data collection timeline.

My observations and responses to the problem-solving conversations, which are the focus of this analysis, were collected via a teacher/ researcher journal. Lesson plans, teaching materials, and student created artifacts will be indications of student expectations and showcase student growth in context, respectfully. Classroom maps and small-group interaction photographs will also be used to help explain the instructional context and student interaction.

Table 3.9: *Data Collection Plan/Timeline*

Time frame	Teacher action	Student action
Week 1	Participant pool briefings (students) begin. - Begin TAR journaling. - Parent meeting invitations are sent home.	Attend briefing and ask questions. Take home invitation.
Week 2	Conduct informational briefings (parents). - Send home consent forms.	Attend with parents. Take home consent forms.
Week 3	Collect consent forms and evaluate candidate pool. - Conduct participant assent process via third-party facilitator.	Return consent forms to TR. Participate in assent process.
Week 4	Begin initial data collection (*Newsela* articles, *Newsela* formative assessments, and traditional textbooks [interested participants]).	All students participate. - Only study participant data is evaluated.
Week 4a	Begin science writer's workshop (Stage A and Stage B). - Collect audio/video recordings. - Write TR notes. - Copy and organize data and artifacts (science writer's workshop packet). - Write CGT research memo.	All students participate. - Study participant data is analyzed. - Writing artifacts of non-participants are not cataloged.
Week 5	Continue collaborative writing stages (Stage C and Stage D). - Audio/video recordings are collected. - TR notes are taken. - Copy and organize data and artifacts. - Write CGT research memos.	All students participate. - Study participant data is evaluated. - Writing artifacts of non-participants are not cataloged.
Week 6	Begin data analysis (first look at collaborative writing data). - Conduct informal, one on one, discussions. - Write research memos following discussions.	Continue with course-related activities. - Students participate in optional, after-school, collaborative writing process feedback discussions.

Chapter Conclusion

This chapter described and discussed the research design of this TAR. The setting, participants, and procedures were also described. Participant volunteers were emerging bilingual eighth grade students in my General Science II classroom in a remote, rural Alaskan village. Constructivist grounded theory processes drove the data analysis and consequently clarified the research question: How do middle school students engage in content learning and in the use of TAL during a science writer's workshop? Chapter 4 follows, explaining the research data and expanding on the methodologies discussed here. Chapter 5 offers my conclusions and implications for further teacher action research in TALA.

Chapter 4: The Research: Data Analysis and Findings

This teacher action research focuses on the languaging processes observed in a middle school classroom during a science writer's workshop. This research specifically investigated how middle school students engage in content learning and in the use of technical, academic language (TAL) during a science writer's workshop. In the context of this research the science writer's workshop is small group-centered, technical, academic language acquisition (TALA) method designed to give students experience in the art of critically thinking and writing about their scientific understandings. As described in the preceding chapter, collaborative student activity data were collected during the spring semester in a science classroom during a life science unit. I documented my wonderings, thoughts, and plans in digital teacher logs, written journals, and lesson plans. Classroom data samples included audio and video recordings, student workshop packets and worksheets from all participants.

I was interested in the pedagogical value of the writer's workshop experience in emerging bilingual (EB) learners' TALA during the teaching of scientific topics. Over the course of the unit, 12 full classroom sessions were recorded and the six most active sessions were later transcribed. In those six sessions 25 specific instances of interactive dialogue were labeled as language-related episodes (LREs) and were provisionally coded for specific student activities, e.g. actions, meanings, processes, agency, etc. per the principles of constructivist grounded theory (Charmaz, 2014, p. 117). Swain and Lapkin (1998) define LRE as "any part of a dialogue where students talk about language they are producing, question their language use, or other- or self-correct their language production" (p. 326). Using constructivist grounded theory, I analyzed session transcripts line by line and assigned initial, student action codes with intent to "define what is happening in the data and to begin to grapple with what it means" (Charmaz, 2014, p. 113). The initial codes were analyzed for emergent (focused) codes that may indicate cogent themes (categories) for further analysis.

This chapter will describe the process of determining the emergent categories observed in my science writer's workshop and explain patterns within students' collaborative interaction and use of TAL within the observed data of two small groups. Specifically, I analyzed for patterns in TAL usage in students' topical summaries (their written products) and in dialogic interaction (their talk) as students composed their topical summaries.

This chapter is comprised of four sections. The first section will introduce the science writer's workshop, providing a look into this alternative TALA method. The second section will walk through the two group narratives to allow the reader to experience the students' writing processes and introduce the focused student activity codes. The third section will introduce and explain the three categories of interest using examples from student's written summaries and student dialogue. The categories of interest will be explained and explored using excerpts from student writing episodes and contextualized with session transcripts as needed. The chapter closes with a section highlighting my findings and insights into the science writer's workshop process.

Background for the Science Writer's Workshop

In the following section I explain both the content instruction the students received prior to the workshop and the science writer's workshop process.

Content instruction.

This unit was intended as a student-centered study of mitosis, asexual eukaryotic somatic cell division. Mitosis appears in the science curriculum following plant/animal cell structure and function and preceding sexual reproduction and Mendelian genetics. This depth of mitosis study was overwhelmingly requested by the class and had not been scheduled in the annual curricular plan. As such it was an excellent opportunity to teach TAL, scientific language, with a literacy emphasis. The teaching objectives were grade-level scientific concepts grounded in collaborative study and tactile experience (Table 4.1).

Table 4.1: *Mitosis Unit Objectives*

Teaching objectives	Target	Objective
Primary	Content	- *Explain* the function of mitosis. - *List* the steps of mitosis. - *Differentiate* the steps of mitosis. - *Identify* the stages of mitosis in cell diagrams and microscope slides.
	Language	- *Draft* an individual summary of the process of mitosis.
Enrichment (sexual reproduction)	Content	- *Identify* and organize the cycle and phases of meiosis. - *Compare* the mitosis and meiosis processes in plant and animal cells.
	Language	- ***CM***® *Compare and Contrast* the mitosis and meiosis processes. - *Revise* a paragraph about meiosis in small groups.

Table 4.2, lists and describes the activities leading up to the science writer's workshop.

Table 4.2: *Details of Pre-collaborative Activities for the Science Writer's Workshop*

Media	*Activity*	Activity Description
Amoeba Sisters mitosis video lecture (animated, YouTube Channel)	*View and Discuss*	Watching this light, cartoon-style video exposed students to the concept of mitosis. In answer to students' requests for clarification other, more technical clips from various sources were shown and discussed as well.
Glencoe© (Blue) textbook (Ch. 10.1)	*Define* mitosis vocabulary *Discuss* asexual reproduction *Discuss* 'the cell cycle' images	Working together as a class we conducted a review of the concepts and vocabulary in the eight-page textbook section.
Newsela® mitosis article *The facts about cells* By *ThoughtCo.com*, adapted by Newsela staff, Text Level **6** 10/17/2017	*Read* and *Sketch* mitosis steps	Reading independently, students studied pertinent portions of this article and sketched the steps. Some expanded their investigations to related on-line articles and wiki-sites to investigate the concept.
Mitosis mnemonic 'wheel' Glencoe© Biology textbook (Ch. 9.1 and 10.1).	*Construct*	Students constructed a free-rotating, three-layered, tactile memory aid relating each phase of mitosis to its function/ purpose. Wheels were retained for future practice.
Prepared microscope slides, onion root tips (Carolina Biological Supply Co.)	*Observe* and *sketch*	Students used microscopes to independently view and sketch prepared, stained slides of onion root tips (a high growth area of the plant) to view the various phases of mitosis.

This workshop followed eight days of engaging, student-driven (self-paced) pre-collaboration instruction using various instructional methods. This is challenging content and textbooks, videos, technical Newsela® articles, and other resources speak of mitosis in various ways. This terminology is new to most science students. The pace is generally fast and the significance of the amazing process of mitosis is lost to many learners because of the new TAL. Teaching cell division with a literacy emphasis is a way to bring the scientific process into focus because it provides students with opportunities to use language as a thinking tool. The acquisition of useful TAL through writing, specifically the science writer's workshop, gives the student time to see and hear the language as they write it, as their partners write and read it, and as they read it themselves.

My essential understanding of the cell cycle and mitosis is shown below and it is at this level that I work to share it. Functional details of the specific phases are omitted for brevity here, but they appear in students' writing. Many deep and relevant extensions stem from the discussion of mitosis; issues of cancer, cloning, genetic disorders, genetic modification, and evolution are only a few.

The two key cell cycle components/ concepts, mitosis and cytokinesis, could be looked at like one looks at the components of a 'semi-truck.' The tractor and the trailer are separate entities often considered as one by laypersons (a semi-truck), whereas industry professionals refer to them as two unique components (a tractor and trailer rig). Similarly, mitosis is often incorrectly joined with cytokinesis because they are sequential occurrences which, when taken together make up the cell cycle. Mitosis is followed immediately by cytokinesis. The topic, explained in my own words as teacher, follows:

The cell cycle is the process of eukaryotic cell division carried out by animals and plants. Eukaryotes have a nucleus which houses their DNA. Mitosis is the phase of the cell cycle that replicates the cell's nucleus.

Mitosis begins with an extended period of cell growth, maturation, and DNA replication: interphase. If you imagine the cell cycle as a circular clock face, interphase begins at the top (12 o'clock) and time passes clockwise. At about eight o'clock on the clock face, prophase begins. In a period of about an hour for most human cells, mitosis replicates the nucleus in four quick steps: prophase, metaphase, anaphase, and telophase (IPMAT). There are now two identical nuclei inside of the cell.

Near 11 o'clock on the clock face, mitosis is followed by cytokinesis, the brief process that splits the cell into two identical daughter cells with one nucleus each. Back at the top of the clock face the two daughter cells now separated begin interphase, the growth, maturation, and DNA replication phase.

When life processes are moving ahead normally this incredibly complex cell cycle repeats continuously, doubling the cells for the life of each cell. Errors in mitosis lead to genetic defects and disorders. When cellular replication processes get out of control, repeating more rapidly, we call it: cancer.

Pre-workshop instruction.

As we began Stage A, Individual and Whole Group Drafting, students had to gather their thoughts on the subject (mitosis) from their various resources. Students worked at their tables with their notes from the previous week's instructional sessions. Each student used their choice of **CM®** *Explain* sentence starters (Figure 4.1) to personally craft a four-sentence paragraph explaining mitosis to me.

To open	▪ ______ is best described as _______. ▪ To define _______, it is necessary to understand ________. ▪ _________ is known for _______, and is important because _______.
To explain or describe	▪ ______ is an illustration of ______. ▪ ______ is frequently referred to ______.
To support your ideas	▪ Critical attributes of ______ include ______ and ______. ▪ A defining characteristic is _______. ▪ The key components are _______ and ________.
To close	▪ An explanation of ______ provides insight into ______. ▪ A complete definition of ________, allows us to _______.

Figure 4.1: **CM®** Explain and Describe sentence starters for essays that explain or describe a topic or concept (figure recreated from the **CM®** Student Flipbook for on-screen use in class).

The members of each table group read their personalized paragraph out loud to their table group. After each student had read their written paragraph I asked the table groups to choose the most useful version of each sentence type (to open, to explain, etc.) and rank them on paper, first, most favorite; to fourth, least favorite.

The Science Writer's Workshop Process

Internalizing TAL requires multimodal learning, reading, writing, and repetition. During the first class session of the workshop, I previewed the repetitive writing-oriented concept of the science writer's workshop process as students followed along in their workshop packets. The workshop packets were six pages (see Appendix C) a cover page followed by a series of lined pages, one page for their individual writings during each stage. Each lined page had brief instructions for the activities of that stage, Table 4.3. Specific details of daily learning targets, student regroupings, etc. were intentionally left out of my explanations during the introductory class session. Chapter 3 clarifies and expands on my adaptation of writer's workshop approach.

The science writer's workshop was conducted in five stages (Table 4.3) and due to unanticipated delays took place over 18 class sessions, the last 12 of which were recorded. The original expectation was for a four-stage, eight- to ten-day series of co-construction sessions followed by post-testing and test revisions as needed before moving on to meiosis and DNA analysis.

Table 4.3: *Science Writer's Workshop Stages*

Name of Stage	Explanation of what students are doing
Pre-workshop Instruction Learning the Concept/ Prewriting	- *Discuss* animated, Amoeba Sisters mitosis video lecture. - *Define* mitosis vocabulary and cell cycle from Glencoe© textbook. - *Discuss* asexual reproduction from Glencoe© textbook. - *Discuss* the cell cycle images from Glencoe© textbook. - *Sketch* mitosis process steps from Newsela® mitosis article (Lexile-level aligned). - *Construct* a tactile mitosis mnemonic 'wheel.' - *Observe* and *sketch* viewed images of prepared onion root tip slides.
Stage A Individual & Whole Group Drafting	Each student used their notes in their notebooks (from pre-workshop instruction) to complete 4 sentence stems, which served as the framework for an explanation paragraph. Each small group compared their individual sentences, and they chose the "best" sentence to suggest to the class. The whole class decided on 8 sentences that fully explained the concept of "mitosis." The teacher wrote those eight sentences on the SMARTBoard. After class, the teacher made typed copies of the eight sentences so each student had a copy for the next stage (3 class sessions).
Stage B Small Group Reflecting & Evaluating	Groups were instructed to work as a group to review and evaluate the eight sentences from the previous stage. Most of the students, however, moved quickly on to Stage C (1 class session).
Stage C Small Group Revising	Students used their own notes and the eight sentences created by the group. The task was to use those resources to work in small groups to revise those sentences to create individual explanations. Students were free to rewrite or combine or add to the "draft" sentences. These conversations were recorded to capture the how students talked about their decisions about what to write (4 class sessions).
Stage D Small Group Revising & Editing	The goal was for students to collaborate in small groups to create a common paragraph. This conversation was recorded. Although the intent was for students to collaborate on one paragraph, each person actually wrote an individual version (4 class sessions).
Stage E Extension: Small Group Drafting, Revising, and Editing	Small groups who had completed their summaries collaborated on a related topic comparison assignment (6, poorly attended, class sessions).

In the reality of our spring semester, the time requirement doubled. Though the small groups co-constructed a written scientific summary, students wrote their own account in their own packet.

Those written summaries were intended to be the result of personal choices and not expected to be verbatim copies, even within the same small group.

A recounting of the activities of the science writer's workshop stages follows.

Stage A: Individual and whole group drafting.

Students were expected to approach Stage A activities with an open mind, a growth mindset. Each student would have a voice in the workshop and a desire to participate, overcoming shyness. As I was leading the co-construction process with the class I modeled the collaborative process. My modeling reminded that we are imperfect scientific communicators, errors are made and must be thought through, and that the collaborative process naturally requires revision.

In the beginning of the co-construction session I stood at the SMARTBoard to post each table group's favorite answers to the query: "How would you explain mitosis?" Though students were not limited to this prompt, their answers would become the seeds of our science writer's workshop. One by one the table-groups told me their favorite sentence or next favorite sentence if another group had already taken their first choice. We went around the students' table groups three times taking one response from each group. After trimming out the repeated thoughts and ideas we had a list of eight original thoughts about mitosis. I wrote each sentence verbatim, as shown in Figure 4.2. As a class, all students were excitedly engaged in the co-construction activity and each wrote the sentences in their notebooks. This sort of low-risk, group-style question and answer activity is non-invasive and students were more comfortable with group activities. Even the more introverted students participated and enjoyed the interaction. It was a great kick-off to our writer's workshop project. Each student was participating and all were writing. It was a pleasant way to model helpful peer to peer interaction before doing so in smaller, more accountable, groups. Note that these mitosis facts are imperfect and roughly composed in their own words. These student opinions, such as they are, are the seeds of our future discussions.

Class work of 05-06MAR18: ***CM*® *Explain/Sequence*** Mitosis Brainstorm

Mitosis is best described as cells produces more DNA material.

Mitosis is frequently referred to as body cell reproduction.

A defining characteristics is a cycle of repeating the same way once.

Mitosis begins when interphase begins. IPMAT: Interphase, prophase, metaphase, anaphase, and telophase. Cytokenesis follows IPMAT.

The next stage was (is) prophase. Cell groups mature / prepares for mitosis.

The next stage for mitosis is metaphase. The chromatids align along equator the cell in metaphase.

Chromatids separate and move to ends for anaphase.

Last but not least the final stage for mitosis is telophase the cytoplasm is beginning to separate.

=== end of class brainstorm ===

Figure 4.2: Stage A, whole class-generated list of facts about mitosis in this co-construction activity.

Stage B: Small group reflecting and evaluating.

In table groups the students were expected to speak up and participate in a low-risk group reflection and evaluation activity, furthering their investment in the workshop process. This stage (Figure 4.3) was provided to ensure students thoughtfully considered their Stage A thoughts as they moved forward in the process, giving them a first chance to revisit their initial writings.

Small-group Feedback:
Read your Group Brainstorm paragraph to your tablemates. When it is your turn to share, share your strongest sentence (the one your group is proudest of) with the class.

Write down all of the shared sentences from the SMARTBoard, here, in the spaces below.

To open: ____

____.

To expand: ____

____.

To support: ____

____.

To close: ____

____.

=======

Rewrite the new, shared paragraph here. Make any noun/verb tense adjustments as you do.

____

____

Figure 4.3: Stage B, Small-group Feedback page from the science writer's workshop packet.

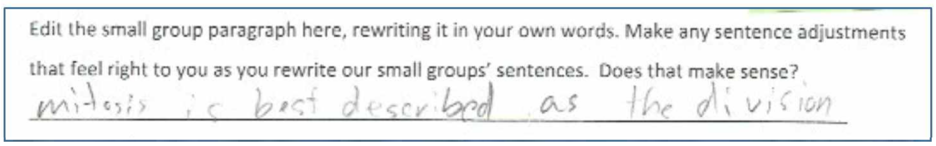
All but two students completely skipped over this step, the small-group feedback page, choosing instead to jump ahead to the Stage C paragraph writing. They bypassed this intentionally repetitive stage and instead completed Stage C on their own. Some students said the format of the Stage B page was, "too confusing." When I asked them why they jumped ahead in the packet, Group 2 said, "paragraph writing was easier to do."

Stage C: Table group revising.

Table groups revised the co-constructed drafts, rephrasing the other table groups' statements into their own words. A heavy wave of unexpected local events and illnesses delayed our transition between Stages A and C. Picking up the project after a three-week hiatus we elected to move ahead while over one-third of the students were absent. I had concerns that the class would lose the flow of our workshop with the lengthy delay, as noted in my journal entries

(TAR Journal, 02APR18). Instead of fading interest however, students pitched in as classroom leaders, actively reengaging our science writer's workshop.

Instead of engaging in Stage B the table groups talked amongst themselves and informally completed Stage C (Figure 4.4), Table-group Revisions by revising the initial brainstorm thoughts to become more or less their own. This peer-to-peer pulling together to get everyone back on task was a great encouragement to us all.


Edit the small group paragraph here, rewriting it in your own words. Make any sentence adjustments that feel right to you as you rewrite our small groups' sentences. Does that make sense?

mitosis is best described as the division

Figure 4.4: Stage C, Small Group Revising page of the workshop packet (instructions only).

Having skipped over Stage B, the table groups went to work on the Stage C assignment, individually assessing and ranking the co-constructed results of Stage A.

Stage D: Small group revising and editing.

Small groups collaborated to produce a topical summary using all the data available to them. Moving to their small-groups I expected that students would build on their previous writings, participating more comfortably in the less formal co-construction process in small-groups, a dyad or a triad. As we transitioned I was working to facilitate the initial small-group conversations. I tried to avoid answering questions, intending to facilitate conversations without steering them. I wanted to allow students to go down a wrong road and resolve their own wonderings and writing challenges was an important consideration. Setting up the recording devices and calming the nervousness of stage fright was my primary task as we began Stage D. Figure 4.5 contains the instruction section of the Stage D science writer's workshop packet.

Co-Construction (pair work):
Discuss the shared, Small-Group Feedback, paragraph with your partner. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic, together. Use any sentences you've seen or heard and modify them however you think best fits the topic.

Strongest option: Work together to create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Any phrases taken directly from articles must be underlined.)*

As you finish your paragraph, *fine-tune* it by test reading the text out loud to make it as smooth and easy to read as you are able. (*Note: You are invited to stand somewhere in the room and read out loud to your partner.*) You may rewrite your paragraph a second time to make it neater if you need to.

Figure 4.5: Stage D, Small Group Revising and Editing page (planned as pair work).

By the end of Stage D, I noted that "after many days of disrupted and disjointed class sessions, students were completed with their work and feeling stressed" (TAR Journal, 16APR18). I inserted a relaxed, round-table discussion in preparation for a new enrichment assignment with intent to "take the creativity and leadership loads off of the students" (TAR Journal, 16APR18). Stage E: Comparison of Meiosis and Mitosis, was inserted into the flow for those ready to move forward the next day.

Stage E: Enrichment assignment.

Small groups who had completed their summaries and collaborated on a related topic comparison assignment moved on to a comparison of meiosis and mitosis. I expected that students would extend the dialogue beyond mitosis (asexual reproduction) conversations and into the more complex topic of meiosis (sexual reproduction), a core biological discussion. Students would compare and contrast mitosis and meiosis both graphically (Venn diagram) and in their topical science summaries. As teacher I expected to be focused on facilitating Stage D wrap-up work and initiating self-led Stage E activities as small-groups transitioned from one to the other.

Stage E included enrichment activities were added at the request of Group 2 who wanted more. It was not expected that all students would have time to move beyond Stage D. The Stage E assignment was intentionally broad, requiring personal investigation beyond mitosis and into the similar, yet more complex concept of meiosis using textbooks and online resources, see Appendix C for the Stage E pages. The Stage E "My *Meiosis* Thoughts" assignment posed some guiding questions and asked for a Venn diagram comparing mitosis to meiosis before writing a one paragraph written summary independently.

As we regrouped at the end of Stage D, I held a one class period, mitosis and meiosis review that was intended to give the students a down-day from the intensity of writing. Coming at the end of their mitosis conversations, this roundtable review session was an opportunity to clarify misconceptions and hear the students' opinions and concerns informally. The informal nature of the roundtable invited students to share their misconceptions and took notes in their notebooks and discussed the more correct connections between mitosis and cytokinesis.

Two Evolving Group Narratives

The following narratives follow the progress of the two target groups through process of the science writer's workshop. Explanations using student's dialogue and written texts are provided to exemplify or illustrate evidence in response to my research questions. Specifically, the three emergent categories in students' collaborative dialogue (teaming, disagreeing, and extending beyond the content). The group narratives are preceded by an explanation of the group reassignment process, and by an explanation of the transcript excerpt and writing excerpt.

The following section describes how each stage of this science writer's workshop proceeded, referring to particular students when appropriate. The final group assignments, Table Group 1 and Table Group 2, formed quite organically due to several unrelated factors.

Each student produced three written artifacts: Stage A writing, Stage C writing, and Stage D writing, which are referenced throughout this thesis. Six participant students were available to provide a fourth sample, Stage 'E' writing. Students' complete written artifacts are located in Appendix C. Writing excerpts are labeled (Author:<Stage A-D>:Line #). Group 1 (Har:A:L1) would refer the reader back to Harry's : Stage A writing : Line number 1.

Transcribed segments of class session dialogue are provided when necessary to contextualize student writing excerpts. Transcripts are labeled by Group, Session, and LRE number. Transcribed LREs are cited as *transcript excerpt* and labeled Group (1 or 2), Session, and Line number(s) (G#:S#:LRE#) in the transcribed sample. The label (G2:S2:L4) would refer the reader back to the transcription of Group 2's : Session 2 : LRE#4.

Table Group One's Process

The following narrative about Table Group 1's work in the science writer's workshop illustrates how these three boys engaged in both the content about mitosis and the scientific language necessary to explain the concept. Table Group 1 included three eighth grade boys; Harry, Matt, and Stu (pseudonyms). Lifetime village residents, social acquaintances, and academic classmates, the boys in Group 1 struggled to maintain a collaborative stance.

The Stage A whole-group drafting session was conducted as an informal, low-pressure, welcome to the collaborative writing process. Each participant reviewed their personal science notebooks and shared the information from our prior instructional sessions that they felt confident speaking about. There was no requirement to speak up during this stage. Students wrote these brainstorm notes in their packets as they saw fit, in words that made the most sense to them at the time.

After Stage A I noticed some trends in their results. Though they worked and talked together while assessing and co-constructing the summary, Table Group 1's written content submissions were not homogeneous across the group; each student clung to some unique beliefs and their work showed thought and consideration; Matt wrote a comprehensive, seemingly well-researched opinion; Stu put in a minimalist effort that met the criteria; and Harry rewrote the whole group co-construction bullets directly.

In Session 2, as they began Stage C Matt and Stu excitedly kicked-off the revision by taking charge. Transcript excerpt 4.1 shows their conversation.

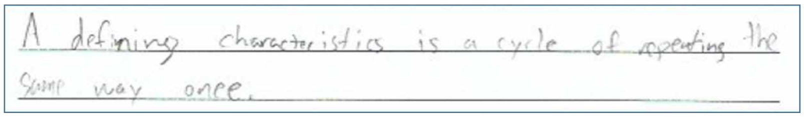
Transcript excerpt 4.1: *Session 2c, Excerpt (LRE#1)*

[1]	Matt: Let's review our mitosis cycle. Mitosis is best described as cells rep-li-cat-ing DNA mat- . . . more DNA and hereditary material.
[2]	S: My first sentence is, mitosis is best described as a division of cells. Harry what's yurs.
[3]	H: Mitosis is described as cell re-clusis more DNA material.
[4]	S: Okay, Matt read your second sentence.
[5]	M: Mitosis is frequentl:y referred to as body production.
[6]	S: <quickly> Mitosis is frequently called the body cell reproduction.
[7]	H: Yeah. Mitosis is frequently referred to as body cell. and...
[8]	S: K. 3rd sentence.
[9]	M: A defining char-ac-teristic is a cycle repeatin itself once.
[10]	S: <quickly>The division of cells is a cycle that always repeats in the same order. Harry your turn, read a sentence.
[11]	H: A defining characteristic ~ is a cycle of repeating the ~~ s::same way:y~~[M: repeatedly] repeatedly.
[12]	S: Repeatedly. Matt, your 4th sentence.

Matt initiates the dialogue and presses the others to share their version of the first of four descriptive sentences that they have written about mitosis. There is notable independence in the writing each brings into the dialogue. As Stu hurries the group along in the conversation, that interesting variety is hardly noted. Stu hurriedly leads on as they read their second sentences. An interesting component of this LRE (Transcript excerpt 4.1) is Stu's repeated interruption of

Harry's reading (Line 7-8, 12), subsequent ignoring of Harry's input. Though Harry parrots "repeatedly," which is spoken three times, "repeatedly" is not included in his writing.

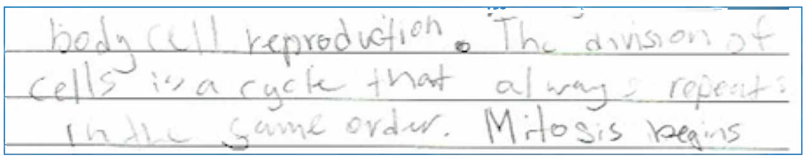
Writing excerpt 4.1 (a-b) contains Group 1's Stage A writing about the process of mitosis, contrasting Harry and Matt's the "*same way once*" with Stu's ". . . in the same order."


A defining characteristics is a cycle of repeating the Same way once.

(Typed: A defining characteristic is a cycle of repeating the same way once.)

a) (Har:A:L6) Harry's Stage A excerpt, ". . . the same way once."

Matt (Mat:A:L3) uses Harry's words, not shown.


body cell reproduction. The division of cells is a cycle that always repeats in the same order. Mitosis begins

(Typed: The division of cells is a cycle that always repeats in the same order.)

b) (Stu:A:L3) Stu's Stage A excerpt, ". . . in the same order."

Writing excerpt 4.1 (a-b): Group 1's Stage A 'mitosis process' writing samples; a) (Har:A:L6) Harry's Stage A excerpt, ". . . the same way once;" b) (Stu:A:L3) Stu's Stage A excerpt, ". . . in the same order."

Earlier in Stage A's whole group sessions Matt had gotten ahead of the class and muddied the mitosis process by adding meiosis details to the mix, details which we as a class had not yet discussed. Using some awkward prose, the class had come to agree that the replication cycle of mitosis continuously repeats itself, "*...the same way once*" (Writing excerpt 4.1.a). This compares to meiosis which repeats a cycle similar to mitosis twice and then, having produced sex cells (eggs, pollen, or sperm), stops. Harry's memory was correct, when compared to meiosis in the group's earlier writings; mitosis repeats the same cycle for the life of the cell, the same way "once." However, Stu's writing (Writing excerpt 4.1.b) is more correct in terms of the larger, biological picture and more appropriate, in terms of his use of TAL.

As their conversation continues, Table Group 1 is collaborating productively. Transcript excerpt 4.2 and Writing excerpt 4.2 (a-c) show the intertwined progression of their dialogic and collaborative writing functions.

Transcript excerpt 4.2: *Session 2c, Excerpt (LRE#2)*

[1] M: Okay. Mitosis starts when <u>interface</u> begins.
[2] S: Okay. Mitosis begins when the <u>interface</u> ~begins(?)
[3] M: No, the <u>interphase</u> cycle begins. [S: yeah]
[4] H: Mito-sis begins when <u>interphase</u> begins <all laugh>
[5] S: That doesn't sound right. Let's change that <chuckle>.

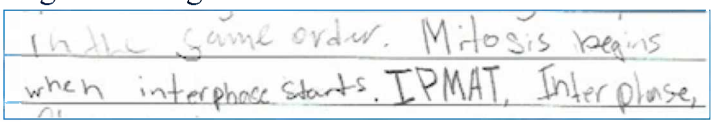
[6] [[S: Mitosis...
[7] [[H: IPMAT, cyto-ki-nesis follows IPMAT.]
<45 seconds of jumbled, confused dialogue breaks out as Group 1 sorts out what they are hearing and reading.>

(Note: <u>Emphasis</u> mine to point out change in word choice.)

Matt initiates the dialogue and is followed by Stu and Harry each reading their contribution aloud from their Stage A writings. As Harry finishes reading his Line 4 they all chuckle at ". . . begins . . . begins." Stu states, "That doesn't sound right. Let's change that" (Line 5). Stu begins to repeat the sentence to co-construct a better version as Harry unaware, reads on without pause. Interestingly, when others are discussing the first phase of mitosis, Harry (Line 7) is making broader connections to the entire cell cycle. Cytokinesis is *not part of* mitosis, but follows it. No one responds specifically to Stu or Harry's Lines 5-7, but a jumble of tumultuous, surprised chatter breaks out followed by two minutes of writing.

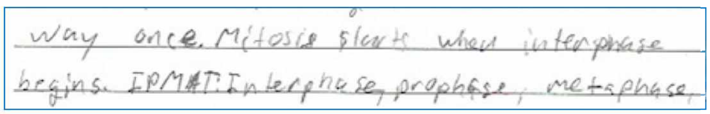
Writing excerpt 4.2 (a-c) accompanies Transcript excerpt 4.2 showing Group 1's Stage A writings. Stu's source writing, "Mitosis begins when interphase starts" (Writing excerpt 4.2.a) is the most well worded. Matt's writing is inverted from Stu's (Writing excerpt 4.2.b), and Harry's incorporates both sources in his original product (Writing excerpt 4.2.c).

Stage A writings:


In the same order. Mitosis begins
when interphase starts. IPMAT. Interphase,

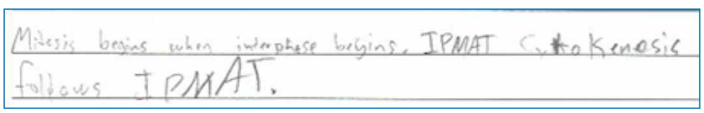
(Typed: "Mitosis begins when interphase starts. IPMAT, <lists stages>. . .")

a) (Stu:A:L5) Stu's writing is grammatically and technically correct.


way once. Mitosis starts when interphase
begins. IPMAT: Interphase, prophase, metaphase,

(Typed: "Mitosis starts when interphase begins. IPMAT: <lists stages>. . .")

b) (Mat:A:L5) Matt's writing is original. He uses a colon to begin the list.


Mitosis begins when interphase begins. IPMAT Cytokenosis
follows IPMAT.

(Typed: "Mitosis begins when interphase begins. IPMAT. <lists stages>. . .")

c) (Har:A:L4) Harry adopts both partners' writing.

Writing excerpt 4.2 (a-c): Group 1's Stage A writings show an interesting relationship. a) (Stu:A:L5) Stu's writing is grammatically and technically correct; b) (Mat:A:L5) Matt's writing is original. He uses a colon to begin the list; c) (Har:A:L4) Harry adopts both partners' writing.

Writing excerpt 4.3 (a-b), shows Group 1's evolving Stage C writings as they are revised during this session. As the group works in this session Stu's text remains unchanged (Writing excerpt 4.3.a), Matt follows Stu's lead, and Harry produces minor transcription errors while adopting Stu's work (Writing excerpt 4.3.b).

Stage C writings:

Mitosis begins when interphase starts.
IPMAT, Interphase, Prophase, Metaphase, Anaphase

(Typed: "Mitosis begins when interphase starts. IPMAT, <lists stages>. . .")

a) (Stu:C:L5) Stu's words are rewritten, unchanged.

Matt's writing now matches Stu's (not shown).

Mitosis begins when Interphase start
IpMat, Interphase, Prophas, Metaphase, Anaphase

(Typed: "Mitosis begins when interphase start. IPMAT, <lists stages>. . .")

b) (Har:C:L7) Harry's format changes to match Stu's, but misses 'starts.'

Writing excerpt 4.3 (a-b): Group 1's Stage C evolution; a) (Stu:C:L5) Stu's words are rewritten, unchanged; b) (Har:C:L7) Harry's format changes to match Stu's, but misses 'starts.

As Group 1 continues their collaborative workshop process the writers are working together more closely. They are building text with one another and leaning on the scaffolding support of one another and yet they struggle to function well as a group. They are sharing more ideas and with less independent thought as they refine their text. Transcript Excerpt 4.3 shows that Harry, Matt, and Stu are intent and on task.

Transcript Excerpt 4.3: *Session 2c, Excerpt (LRE#4)*

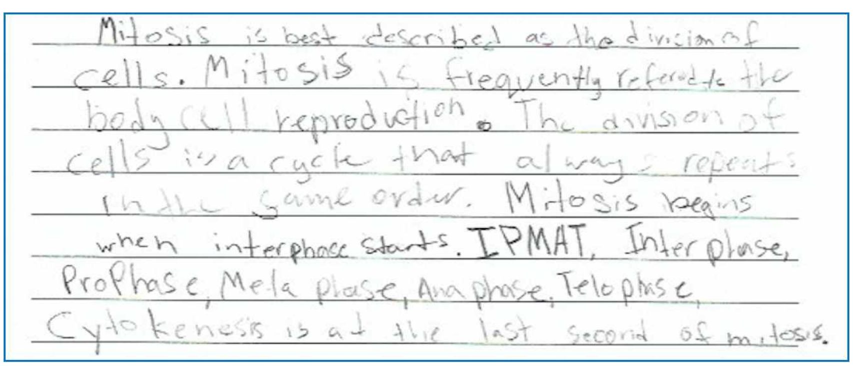
[1]	S: Mine is like Matt interphase, prophase, metaphase, anaphase, telophase, cytokinesis is- at the last second of mitosis. *<45 seconds of mutually silent writing>*
[2]	S: IPMAT is
[3]	H: the next stage ~~~ was- ~~~~~ or, the next stage is
[4]	M: is *<Stu glances at Matt's writing>*
[5]	S: How did you guys get while I got, this...? MAN I gotta' go to the bathroom.
[6]	H: cell group material <chuckles> pre-pared for mi-to-sis. Yur turn Matt.
[7]	M: K. ~~~ The chromatids align along the equator, the ce- in equator of the cell in...
[8]	[S: Wait how did you guys get that? Matt, tr-tr-try look at mine. Is mine right? Tr-try ah-]
[9]	M: It. You never you never ah put a~ um, you you're um~ body never made a
[10]	H: <interrupts> You left m' pencil.

Harry and Matt are jointly constructing a sentence about metaphase and conjugating the past or present forms while reading out loud from their Stage A pages. At Line 5 Stu pauses his writing and looks up from his paper. Believing that Matt is not writing the same things he had been, Stu gets a little frantic and, on Line 8, he is stuttering under the stress and expressing insecurity of the moment. Matt gives some unrecognizable assistance and Harry, chuckling, ignores Stu's plea.

While Stu is out of the classroom Harry is attempting to engage Matt, who is silent, seemingly put off by Harry's efforts. After Matt disengages with Harry on Line 2, Harry picks up Stu's notes (Writing excerpt 4.4), reading them aloud in a slightly affected presenter's voice ending with, "I didn't – know that!" (Transcript excerpt 4.4).

Transcript excerpt 4.4: *Session 2c, Excerpt (LRE#5)*

[1] H: Which one's the best~ paragraph? Hm-hm-hm!?
[2] M: I dunno. I'm just~ writing notes. Anaphase and telophase.
[3] H: See his <reaching Stu12's packet>... Mitosis is best described as TH::E division- of cells. Mitosis is frequently called the body cells {?}.
[4] H: The division of cells is a cycle that always repeats in the same order. Mitosis begins when interphase starts. IPMAT.
[5] H: Interphase, prophase, metaphase, anaphase, telophase, cytokinesis, last second of mitosis.
[6] H: I didn't – know that!


Mitosis is best described as the division of cells. Mitosis is frequently referred to the body cell reproduction. The division of cells is a cycle that always repeats in the same order. Mitosis begins when interphase starts. IPMAT. Interphase, Prophase, Meta plase, Anaphase, Telophase, Cytokenesis is at the last second of mitosis.

Writing excerpt 4.4: Stu's writing from Session 2c.

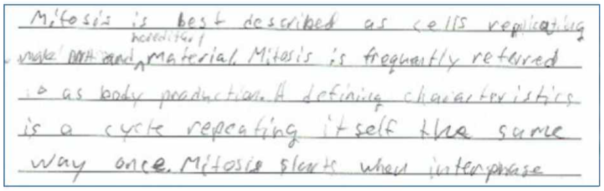
The class period is coming to a close and Stu has returned to discover that Matt has done little or no writing in his packet this day. At this same time, with a mashup draft of his partners' sentences on his paper, Harry—frustrated—leaves the table to walk about the room for a bit. Transcript excerpt 4.5, Line 3, shows that Stu is pressing Matt to get his paragraph completed before class ends. Having no revisions on paper Matt is pressured to copy directly from Stu's paper. As Matt slowly writes out loud Stu becomes increasingly disagreeable, more agitated, and more caustic in his responses (Line 5-9). Matt's replies are becoming pointed as well. As Matt methodically finishes his writing Stu looks over and dismissively states, "let's do mine." I read this to mean "yours is not good." Matt replies, "ouch," then bumps into the table with his knee saying "ouch" again.

Transcript excerpt 4.5: *Session 2c, Excerpt (LRE#7)*

[1] S: Look. Mitosis is best described as the division of cells.
[2] M: oh yeah on this...
[3] S: 'k. Um. Try read your second one, your second sentence.

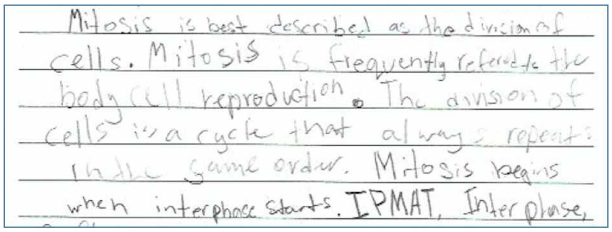
[4] M: I never wrote anything yet.
[5] S: YOUR second sentence, Matt's second sentence!
[6] S: 'k, right it down.
[7] M: Mitosis is frequently referred~ to as body, cell, production
[8] S: re-production!
[9] M: Reproduction, there are you happy?
[10] S: Yeah, let's do mine.
[11] M: Ouch. <thump> ouch <Matt banged knee on table leg>.

In conjunction with Transcript excerpt 4.5 above, Writing excerpt 4.5 (a-c) (next page) shows Matt's earlier (Stage A) draft (Writing excerpt 4.5.a), his initial interpretation of the data. Writing excerpt 4.5.b shows Stu's writing, the words he's using to guide Matt's success in this moment. Under duress to complete an incomplete assignment, Matt essentially completed a copy of Stu's (Writing excerpt 4.5.c).



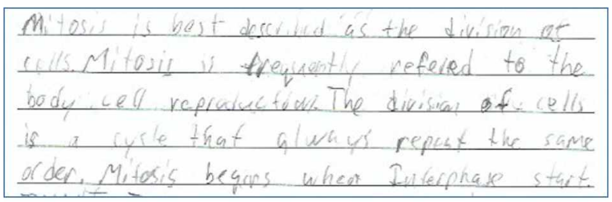
(Typed: “Mitosis is best described as cells replicating more DNA and hereditable material. Mitosis is frequently referred to as body production. A defining characteristics is a cycle repeating itself the same way once. Mitosis starts when interphase [begins].”)

a) (Mat:A:L8) Matt's original writing



(Typed: “Mitosis is best described as the division of cells. Mitosis is frequently referred to as body cell reproduction. The division of cells is a cycle that always repeats in the same order. Mitosis begins when interphase starts.”)

b) (Stu:A:L1) Stu’s sentences.



(Typed: “Mitosis is best described as the division of cells. Mitosis is frequently referred to the body cell reproduction. The division of cells is a cycle that always repeat the same order. Mitosis begins when interphase start.”)

c) (Mat:C:L1) Matt's rewrite, a near copy of Stu's writing.

Writing excerpt 4.5 (a-c): Matt's revised writing under pressure. a) (Mat:A:L8) Matt's original writing; b) (Stu:A:L1) Stu’s sentences; c) (Mat:C:L1) Matt's rewrite, a near copy of Stu's writing.

As we began the next class session Harry is losing his confidence and wanting to disengage and is putting his head down. I stepped over to Harry, cheerfully encouraging him to keep a positive attitude and ask his friends for help. Harry begins the dialogue (Transcript excerpt 4.6) with a lazy request on Line 1. Stu offers assistance by reading Harry’s writing out loud and closes with a recommendation, “the fifth and final cell is anaphase” (Line 3).

In terms of the content, Stu’s insertion of *cell* in “the fifth and final cell. . .” is confusing, a misspoken recommendation. I believe he intended to state, “fifth and final *phase*…” of mitosis.

Transcript excerpt 4.6: *Session 4c, Excerpt (LRE#2)*

[1] H: Will you let me copy?
[2] S: No, not copy, jeez!
[3] S: Hmmm <reading Harry's paper> {??}phase, anaphase, prophase, interphase, there's metaphase, IPMAT. You need anaphase now. The fifth and final cell is anaphase.
[4] M: It's not final, uh cytokinesis.
[5] S: No(^), cytokinesis is a different thing. Cytokinesis isn't part.
[6] S: Last one.
[7] M: Cytokinesis is part of mitosis. Part.
[8] H: <writing out loud> Ana-phase.
[9] S: <in condescending cartoon voice> Anaphase is the 1 - 2 - 3 - 4th one. The 5th one is telophase. The 6th one is cytokinesis.
[10] H: <to Matt> He told me to write "the fifth and final cell."
[11] S: Oh Matt do it again, <pointing> right here.
[12] H: You too Matt, mistake!
[13] M: I-I never did that.
[14] S: I got chills. <shoulder rub finishes>

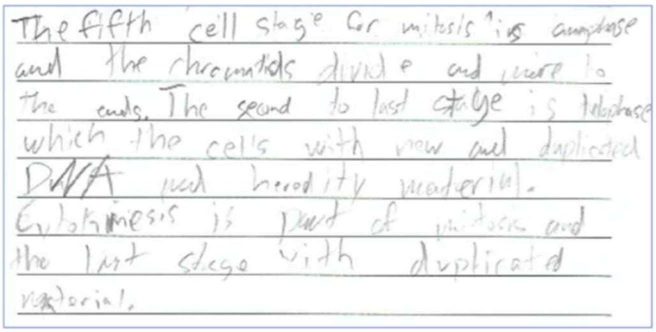
[15] H: 'k what do I write after anaphase?
[16] S: O::::h my shoulder feels funny, but cool <all LLL>.

[17] [[S: Cell is anaphase. is, dashed line
[18] [[M: The fifth and final s . . . that is described. . .
[19] H: I d'know!?

[20] S: You, you have a folder for a reason, you have all your notes in it.

Stu's instructional statement invokes Matt's interjection (Line 4) that there's more to mitosis. Matt has misstated the science here. Cytokinesis is separate from mitosis. Stu disagrees and in Lines 5 – 7, he and Matt go back and forth about it. Without confronting Matt, Stu moves on with Harry. Stu makes a scene by loudly and satirically counting the phases of mitosis out for Harry on Line 9 and in the moment misstates facts. Stu's belittling comments changed the tone of the dialogue. On Line 10 Harry engages Matt, blaming him, pointing out the lack of a sixth phase on Matt's paper, and Matt disagrees.

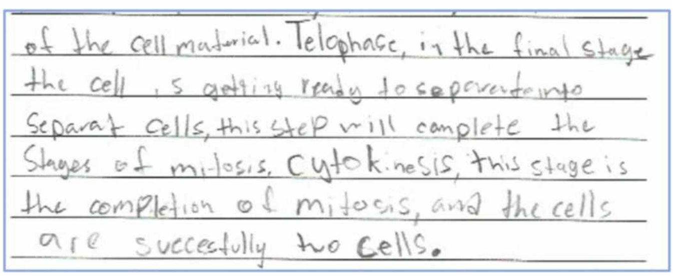
The dialogue ends with Matt offering help to Harry. As Matt and Stu simultaneously offer different ideas, Line 15-20, Harry becomes instantly overwhelmed, possibly at a loss for which trusted friend to follow.


The fifth cell stage for mitosis is anaphase and the chromatids divide and move to the ends. The second to last stage is telophase which the cells with new and duplicated DNA and heredity material. Cytokinesis is part of mitosis and the last stage with duplicated material.

(Typed: "*The fifth cell stage for mitosis is anaphase and the chromatids divide and move to the ends. The second to last stage is telophase which the cells with new and duplicated DNA and heredity material. Cytokinesis is part of mitosis and the last stage with duplicated material.*")

a) (Har:C:L14) Harry's writing incorrectly relates the fifth stage as anaphase per Matt, his peer-advisor. Harry also incorrectly states that cytokinesis is part of mitosis.

Matt's writing (Mat:C:L13) is identical to Harry's, not shown.


of the cell material. Telophase, is the final stage the cell is getting ready to seperate into separat cells, this step will complete the stages of mitosis. Cytokinesis, this stage is the completion of mitosis, and the cells are succesfully two cells.

b): (Stu:C:L14) Stu's unique closing paragraph.

Writing excerpt 4.6 (a-b): a) (Har:C:L14) Harry's writing incorrectly relates the fifth stage as anaphase per Matt, his peer-advisor, b) (Stu:C:L14) Stu's unique closing paragraph.

Harry made up a lot of ground during this session. He has also received some incorrect guidance from both Matt and Stu, on whom he most depends. Harry also infused a few transcription errors in the first half of today's writing, see Writing excerpt 4.6 above. Having gotten incorrect advice from Stu, Harry bypasses the more correct data on his paper and writes 'anaphase is the fifth of six phases' using Stu's trusted words (Transcript excerpt 4.6, L12). Harry correctly follows anaphase with telophase, but he misstates the functions of telophase. Matt's incorrect advice leads Harry to close with the inclusion of cytokinesis as the last stage of mitosis, a false statement.

Harry and Matt's identical, unclear writing may demonstrate weaknesses promulgated by copying. Errors are significant on both participants' writing in that Lines 16 and 17 are at least incomplete and a mashup of ideas, ". . . *is telophase which the cells with new and duplicated DNA and hereditary material* <.>" (Har: C:L17-18 and Mat:C:L16-17, respectively).

In Writing excerpt 4.6b above, Stu's writing (Stu:C:L14-18) is accurate, contrasting sharply with Harry and Matt's. Stu does, however, erroneously pull cytokinesis into mitosis on Line 18.

As it is my habit to round in the student's behalf, it is worth noting for Stu's benefit that a key word changes the outcome. Though lines 16-18 read like a second closing sentence that disagrees with his words in lines 14-16, exchanging the word "mitosis" for "cell cycle" on Line 17 makes Stu's ending textbook correct. This single sample of Stu's writing demonstrates the only use of the term in all of Group One's dialogue. In his hurry to get all three of these paragraphs completed in the last minutes of the last day, Stu may have simply made a mistake. For the record, Stu confirmed his understanding that "cytokinesis is not a part of mitosis" in the post-test.

Teacher reflections and interpretations—Group 1.

There is a flow, a dialogic thread of change, in Table Group 1's work. Each student participated in the dialogue and engaged in useful, collaborative writing. Working together they *teamed* a bit and brought independent views, disparate thinking and perspectives, into the conversation. After a few LREs the group began to collaboratively build ideas together as their dialogue became a more interdependent experience (Kimmerle et al., 2017). Their vacillation between dyadic interaction modes—*Dominant/Dominant*, *Dominant/Passive*, and *Collaborative pair* (Storch, 2002)—seemed to increase their struggle to be successful as a group.

Often at odds and more argumentative than collaborative, Group 1 still had many solid moments of co-construction. It seemed as though their disagreements were not necessarily negative interactions. Sometimes their differences brought about *negotiating talk* and moved the conversation forward. More often, however, Group 1's interactions were seen to be *banging heads*, with each participant asserting their own opinions while *negating* others'; "seeking closure" (Johnston, 2012, p. 63) with each individual pressing the group to converge on his personal, more correct, view of mitosis. Though they have several productive conversations as a group, the struggle between Matt and Stu seems to bring more head-banging and negating and less collaboration, less of the kind of disagreement that leads to teaming. This appears to frustrate Harry, who does not know which trusted friend to follow. This prompts me to think about what I might have done to encourage more negotiating talk, more productive dialogue when disagreements arose.

During Stage E, the entire group completed the meiosis question and answer review sheet, and Matt and Stu completed the Venn diagram. Eventually Matt completed all of the Stage E work. Due to the heavy absenteeism there was no significant co-constructive dialogue during Stage E, and that assignment was primarily completed as independent work in this group. As such there is no analysis of Stage E writings.

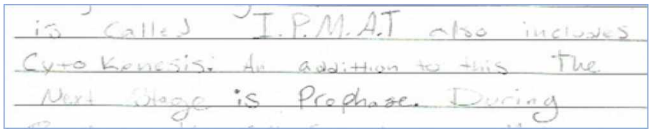
Table Group Two's Process

This narrative follows key conversations in Table Group 2's science writer's workshop experience as this two-girl dyad processed the scientific content (mitosis) while becoming more at ease with the TAL needed to explain the concepts. Table Group 2 included Helen and Tommie (pseudonyms), eighth grade girls. The girls are newly introduced colleagues who operate in different social circles at school and live in distant parts of the village; Group 2 is instantly and almost constantly collaborative.

After Stage A, Individual and Whole Group drafting (co-construction), I noticed some trends in their work at separate tables. Helen and Tommie worked confidently. Previously, when sitting at Table Group 3 and Table Group 2, respectively, each had led their table groups. Because they were strong and independent workers, I had planned on them working in different groups during Stage D.

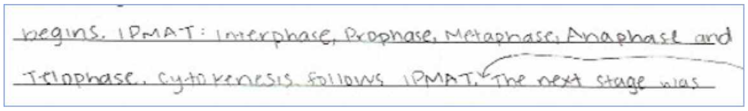
By the third day of attempted Stage D, Small Group Revising & Editing, table groups two and three have had many growing pains. Absentees, illnesses, and exhausted kids have dramatically affected the work. Tommie's good friend and non-participant colleague completely shut-down on day one, leaving Tommie to work on her own. Day two brought Tommie's colleague Brie back to class with an ice pack and an unresponsive demeanor, still feeling ill. Tommie was on her own once again. Day three brought some reorganization to help out Table Groups 2 and 3. I relocated Helen and her non-participant colleague from Table Group 3 to Table Group 2.

Stage C had been completed separately by Helen and Tommie at their original tables in collaboration with their prior partners. Writing excerpt 4.7 (a-b) show key differences in their Stage C points of view as Helen and Tommie begin Stage D together.


is called I.P.M.A.T also includes
Cyto Kenesis. In addition to this The
Next Stage is Prophase. During

(Typed: . . . *I.P.M.A.T also includes cytokinesis. Cytokinesis is involved within I.P.M.A.T.*)

a) (Hel:C:L10-12) Helen's independent Stage C writing is unique.


begins. IPMAT: Interphase, Prophase, Metaphase, Anaphase and
Telophase. Cytokenesis follows IPMAT. The next stage was

(Typed: *Cytokinesis follows IPMAT.)*

b) (Tom:C:L5-6) Tommie's independent Stage C writing is unique.

Note: Helen and Tommie bring unique perspectives into their Stage D collaborative writing session with their independent writings. There are other subtle differences, but this one is most germane to this discussion.

Writing excerpt 4.7 (a-b): Helen and Tommie's independent writing data set; a) (Hel:C:L10-12) Helen's independent Stage C writing is unique; b) (Tom:C:L5-6) Tommie's independent Stage C writing is unique.

Stage D, Small Group Revising and Editing, Session 4.

Helen has been off-task with Table Group 3 and has completed her Stage C writing with a quiet colleague <female student non-participant>. Tommie's Table Group 2 has been off-task but she has written out her mitosis paragraph independently. I introduced Helen and her quiet colleague to Tommie and got them talking with a guiding response,

> Your three opinions are going to be different <student eyebrows rise, questioning me>, and that's actually great. Don't just copy each other's work. Absorb it and then put it out together . . . in your words.

After a little table talk Helen replies "Sssso we read to each other for a while and then we discuss it?" I thumbs-up and walk away. Being well-read, sharp thinkers with two, Stage D, warm-up sessions behind them for additional preparation, Helen and Tommie were ready to go. After some social chat Helen and Tommie are ready to begin work with or without the active participation of their third member. After just a few moments of talk these girls were on the same wavelength, merging their *independent* thoughts into full on collaborative dialogue from the beginning. The silent, third student is effectively out of the dialogue, but participates in thinking and writing.

Transcript excerpt 4.7, begins as Helen opens the dialogue after some silent reading and writing, eight minutes into their first meeting. Tommie offers answers to fill in the blanks of Helen's thoughts. Helen's think aloud on Line 1 opens a joint communicative space that frames this moment of peer inquiry. Tommie volleys back to begin the collaboration and her responses are spot on. They are already working as a team. Tommie's responses to Helen's rhetorical questions allow Helen the space to synthesize a more correct response. Afterward they pause to write their synthesized answer, they are already acting interdependently.

Transcript excerpt 4.7: *Session 4a, Excerpt (LRE#1)*

[1]	H: Mitosis is known as . . . known as what?
[2]	H: Mitosis is known as . . .
[3]	T: Cells reproducing?
[4]	H: Mitosis is known as cell reproduction.
[5]	T: Cell reproduction?
[6]	H: Um-hm.

In Transcript excerpt 4.8, Table Group 2 continues the conversation, building their essential understanding of mitosis. Helen initiates and carries the dialogue on her own as she wrestles with completing her thought (Line 3). Tommie follows Helen's lead contributing to the sentence (Lines 4 and 5). Helen closes by confirming "the cycle of IPMAT" (Line 9), a correct definition of mitosis. The partners write independently for another minute. The group's dialogue and independent writing converge to match closely.

Transcript excerpt 4.8: *Session 4a, Excerpt (LRE#2)*

[1] H: Mitosis' known as cell reproduction. What~? <rhetorical>
[2] H (?): °Mitosis is known as cell repro-duc-tion~ repeating.°
[3] H: Mitosis' known as cell reproduction repeating~ every cycle? No, not every cycle. Repeating it. . .
[4] T: Repeating~ it-itself.
[5] T: No. haha. Mitosis is known as cell reproduction repeating~~ [H: it] Wait. Repeating, um~~ the cycle?
[6] H: The cycle of It.
[7] T: I forgot what I just said.
[8] T: Repeating what?
[9] H: IPMAT. Repeating the cycle of IPMAT.

Transcript excerpt 4.8 (a-b) (above) illustrates the similarity of the group's written language. As the group moves ahead they struggle with a key technical term, cytokinesis. As they begin to dig for the term, Tommie remembers and checks her notes. Unheard by Helen, she speaks it, "cytokinesis" in Line 4. In their digging they test homophones from their memory of the target word. Possibly doubting her comment in Line 4, Tommie tosses out another option, cytoplasm, a related science term in Line 7. In the Line 9 of Transcript excerpt 4.9, "including cytokinesis" is spoken for the first time.

Transcript excerpt 4.9: *Session 4a, Excerpt (LRE#3)*

[1] T: I almost write impact.
[2] H: Including cy-cyc-cccych-rr-kinesis? [T: Oh!?]
[3] H: Including.
[4] T: Cy-cyt-ccc~ wait I know <page turning> cytokinesis.
[5] H: Cyto. Cyclo. Cyclops.
[6] ~~H: Can you put thick skulls in a boy or girl got mixed up bones?~~
[7] T: . . . {let's add} cy-to-plasm.
[8] H: plasm. Eww, plasm <haha>.
<brief writing recess from speaking>

[9] H: Mmm. Including cytoclops. Wait. yeah.
[10] T: cyt ~ Cytokinesis

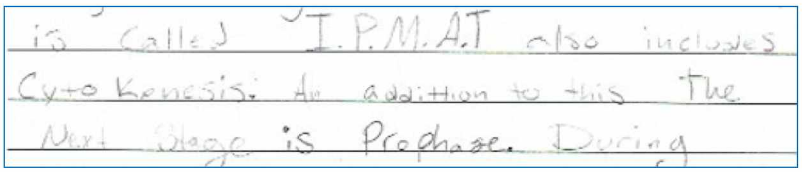
As the conversation develops the girls are dialoguing while writing independently (Transcript excerpt 4.10). Helen wants to include cytokinesis as a part of mitosis as she is considering the linguistic register of their paragraph (Line 1). Tommie offers her opinion on Line 2 and seems to waffle in her confidence, thinking aloud as she had done in Transcript excerpt 4.9, above. Helen seems to be holding a separate conversation as Tommie is asking herself (out loud) about including cytokinesis in Line 3, and convinces herself, “yah,” in Lines 6 and 7. This moment of convergence flowed out from Tommie. It makes me wonder if she’s reticent to let her prior knowledge go. It seems she is showing agreement with Helen’s alternative viewpoint on the relationship between mitosis and cytokinesis and yet not really believing it deeply.

Transcript excerpt 4.10: *Session 4a, Excerpt (LRE#4)*

[1] H: Including cytokinesis. Should we say including or something smarter? <LLL>
[2] T: Um, mi-tosis is known as cell production repeating the cycle of IPMAT. While~ cytokinesis follows it?
[3] T: Hm, n:o. Including cytokinesis. Yeah? or no? [H: Should we?] is known as {???} repeating the cycle of IPMAT.
[4] H: What do you got?
[5] H: °Okay,° our.
[6] T: Including? Just say including, yah.
[7] T: That's right. Mitosis is known as~ the cycle IPMAT. What did you say? ~~instead of also. Oh, in addition to this. Nope, nope, nope.
[8] H: If you want to make essay longer change also to "in addition to this." That's a good one for essay.

On Line 7 Tommie writes and thinks out loud as she is considering Helen’s “in addition to this,” paragraph stretching clause. Tommie seems to toss it out on its face. The dyad digress and talk about the usefulness of Tumbler, an internet-based social media site and the source of Helen’s Line 8 comment, for the final ten minutes of the class session.

Helen’s workshop writings have used the more academic, “also includes” and “in addition to this” since the beginning. Conversely, Tommie has used more colloquial speech throughout and is being swayed from her core belief that “cytokinesis follows IPMAT” (Transcript excerpt 4.10, Line 2, above). The reversed statement, “including cytokinesis” is now appearing in Tommie’s writing. Looking at Helen’s previous writings and Tommie’s writing on this day, Writing excerpt 4.8 (a-b), shows that both students may even be thinking from a differing perspective.


is Called I.P.M.A.T also includes
Cyto Kenesis. An addition to this The
Next Stage is Prophase. During

a) Helen’s Stage C writing shows her use of “also includes” and “in addition to this” in a slightly different way before joining Tommie in Table Group 3.

“Mitosis is known as cell reproduction repeating the cycle of IPMAT. Including cytokinesis.”

(typed by TR, original scan was corrupted/unreadable)

b) Tommie’s Session 4 (Stage D) writing.

Writing excerpt 4.8 (a-b): Connections to academic language.

Teacher Reflections/ Interpretations—Session 4.

Here in Session 4 Helen and Tommie are conversing together for the first time. Unbeknownst to them they have opposing opinions about the relationship between mitosis (abbreviated as IPMAT) and cytokinesis. These girls’ ideas have been converging since the start of this day’s writing session, both dialogically and in their writing, but it is Tommie whose opinion/perspective is changing/being changed.

As Helen moves ahead to merge their two processes she is changing Tommie's perspective and Tommie is quietly resisting. By the end of this session Tommie has capitulated to add "including cytokinesis," and her process seems to show that she is struggling with both denial and acceptance.

The co-construction of their newly shared thought that 'cytokinesis is a part of mitosis' during this session follow:

- The partners co-construct a definition of mitosis and begin to describe the process.
- They introduce/remember cytokinesis from prior knowledge. Helen verbally includes cytokinesis with mitosis as they pull this familiar term out of their memories and notes.
- Tommie struggles with herself about Helen's inclusion of cytokinesis as a part of IPMAT. The processes are separate and she knows it.
- By the end of the class session Tommie has begun to capitulate, adding Helen's words "including cytokinesis" to her own statement.

Stage D, Small group revising and editing, Session 5.

As Session 5 (the subsequent class period) began, Group 2 settled in to continue yesterday's Stage D work (Transcript excerpt 4.11, next page) in their writer's workshop packets. These writing samples can be found in Appendix C.

The group is collaborating to link IPMAT to cytokinesis. As they interact they are wordsmithing here, not writing. Here, Helen proposes adding "involves" (Line 2), and in Line 4, requesting Tommie's opinion about the phrasing. In Line 5 Tommie restates Helen's phrase, removing "involves" as she speaks (referring to Line 2). I wonder if this could be a subtle fallback to her researched understanding that mitosis is not attached to cytokinesis. The group works at it and chooses "involves" as a more useful alternative (Lines 9-11).

Transcript excerpt 4.11: *Session 5a, Excerpt (LRE#1)*

[1] TR: Hm-mm a word for including?
[2] Helen: "In addition to this involves cytokinesis."
[3] Tommy: Yeah.
[4] H: Does it hear good for the sentence?
[5] T: In addition to this, cytokinesis
[6] [TR: A longer word for what? Including?]
[7] H: I forgot what I said.
[8] T: ME TOO!
[9] [[H&T: <LLL> In addition to this~]]
[10] H: Man, I had good word for including!
[11] T: Involves!
[12] H: Yah, involves.

As the group is refining "in addition to this-- involves" (Transcript excerpt 4.12, Line 1-5) in their mutually designed sentence, Helen offers "involves . . . " (Line 3), Tommie immediately modifies, and Helen modifies that. By Line 7 they have lost themselves in the words, prompting a repeat.

Transcript excerpt 4.12: *Session 5a, Excerpt (LRE#2)*

[1] [[T: I addit-]]
[2] [[H: Wh-what did we said.]]
[3] H: In addition to this-- involves.
[4] T: In- cytokinesis is involved.
[5] H: With::: IPMAT.
[6] T: Within- it's. Okay.
[7] H: Wait [T: Wait(^)] what? <LLL>
[10] T: In addition- I joke.
[11] H: Oh my god, we-
[12] T: In addition to this(^)~ CYTOkinesis is involved, yah, cyt-
[13] H: In addition to this cytokinesis [[is involved~~~]].
[14] T: [[is involved.]]
[15] H: What else should we say?
[16] T: Within IPMAT. [[Yah.]]
[17] H: [[Yah.]] Jinx.

In Lines 12-14 they read back the entire sentence Tommie first, unsure, then Helen. Having read it through, Tommie agrees adding "within IPMAT" (Line 16)

Transcript excerpt 4.13 and Writing excerpt 4.9 (a-b) show that in the process of refining their TAL, the group is moving toward more academic speech patterns "in addition to this" and "is involved in" and though the formality still seems awkward for them, they work toward applying the more academic prose.

Picking up from Helen's previous work Tommie is now offering "in addition to this" in their new sentence (Transcript excerpt 4.13). Slightly out of sync, Helen offers "IPMAT involves . . . " (Line 2) but Tommie butts in prompting Helen to read back the entire sentence as amended without a pause. Having heard the words "is involved in IPMAT" spoken, Tommie seems to be revisiting her thoughts (Line 4, 6, 8). She may again be realizing that this completely opposes to her earlier research and Stage C writing (Writing excerpt 4.7, Tom:C:L6) at the beginning of this section. Tommie knows that Helen's ". . . cytokinesis is involved with IPMAT," is false.

Transcript excerpt 4.13: *Session 5a, Excerpt (LRE#3)*

[1] T: In addition to this~ That sounds weird. You need to add another word. In addition to this~
[2] H: IPMAT involves~ [T: No (^). In addition-] "In addition to this cytokinesis~~ is involved in IPMAT."
[3] H: Wait.
[4] T: Nope. That's not true.
[5] H: In addition to this also means also. [T: Yeah] Also. <<LLL>>
[6] T: In addition to this~
[7] H: You got anything?
[8] T: Cytokinesis is involved?
[9] H: Within IPMAT. [T: Yah.] Yah.
<both erasing>
[10] H: In or an [T: Wait].
[11] T: In addition~~ to this~~ ~~ ~~ ~~ I forgot.
[12] H: Same.

In Lines 9-10 (above) they come full circle, questioning and again agreeing that "cytokinesis *is involved* within IPMAT," causing them to erase yesterday's words and rewrite their sentence. This LRE ends with the girls seemingly forgetful of their progress. However, this is the last mention of the mitosis-cytokinesis connection during the workshop. Tommie and Helen may be dismissing the struggle for good as they speak Lines 11 and 12 and move on.

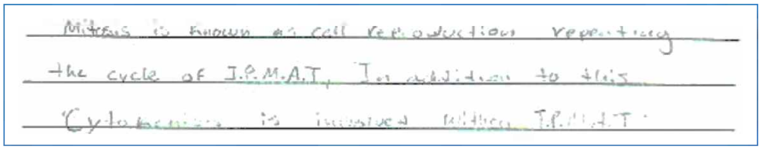
As the dyad finishes the day they are off topic but they momentarily return and consider the form of the last sentence. Together on Line 2 they decide to write about "the mitosis steps" beginning with interphase.

In Transcript excerpt 4.14, Helen makes a weak grammar choice (Line 5) and in a roundabout way Tommie corrects her singular "is" to the plural "are" (Line 8). All chuckle at the only slightly longer replacement word "are" for "is."

Transcript excerpt 4.14: *Session 5a, Excerpt (LRE#5)*

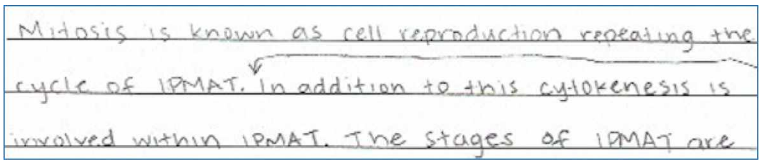
1) T: I'm just going to write-
2) H: Should we talk about the mito- mitosis steps?
3) T: Yeah.
4) T: Interphase?
5) H: The stages of IPMAT is, and we do the-
6) T: I almost write impact again. [H: Like I did!]
7) H: What's a longer word for is?
8) T: Are?
9) <<LLL>>

As they quickly complete their writing of the remaining phases of mitosis the conversation moves forward unchallenged though Tommie realizes she has skipped an important statement early in the sequence. Writing excerpt 4.9(a-b) shows how Tommie writes the sentence about the missed step at the end of the paragraph and loops the arrow up to the insertion point to avoid rewriting the entire paragraph. The insertion of these arrows in Tommie's writing admits mistakes to readers. These are growth moments worth noting. Handwritten drafts are often crumpled and thrown away when excessive errors are discovered.


Mitosis is known as cell reproduction repeating the cycle of I.P.M.A.T, In addition to this Cytokenisis is involved within I.P.M.A.T

(Typed: "Mitosis is known as cell reproduction repeating the cycle of I.P.M.A.T, In addition to this Cytokenisis is involved within I.P.M.A.T")

a) (Hel:D:L1-3) Helen's excerpt, ". . . repeating the cycle of IPMAT" (Line 9).


Mitosis is known as cell reproduction repeating the cycle of IPMAT. In addition to this cytokenesis is involved within IPMAT. The stages of IPMAT are

b) (Tom:D:L1-3) Tommie's excerpt, ". . . repeating the cycle of IPMAT" (Line 9).

Note: Group 2's collaborative writing is in agreement as they finalize the critical concepts of their

Writing excerpt 4.9 (a-b): Session 5 rehash of Session 4's work, "cytokinesis is involved within IPMAT;" a) (Hel:D:L1-3) Helen's excerpt, ". . . repeating the cycle of IPMAT" (Line 9); b) (Tom:D:L1-3) Tommie's excerpt, ". . . repeating the cycle of IPMAT" (Line 9).

In this brief, heavily off-task, and somewhat repetitive, session Tommie began revising and reorganizing her previous writing. Tommie's collaboration with Helen produced four lines of text that completely reverse her prior knowledge. Lines 2 and 3 (Writing excerpt 4.11, Tom:D:L1-4) in comparison to line 6 in her earlier writing, Writing excerpt 4.10 (Tom:C:L1-6) shows Tommie writing that "cytokenesis (sic) follows IPMAT." This was her original thinking and the position she clung to until interacting with Helen here in Stage D.

[1] Mitosis is best described as cells reproducing more DNA
[2] material. Mitosis is reffered more to as body cell
[3] reproduction. Defining a characteristic is a cycle of
[4] repeating the same way once. Mitosis begins when interphase
[5] begins. IPMAT: Interphase, Prophase, Metaphase, Anaphase and
[6] Telophase. Cytokenesis follows IPMAT. The next stage was

Writing excerpt 4.10: (Tom:C:L1-6) Stage C's writing,"cytokenesis follows IPMAT."

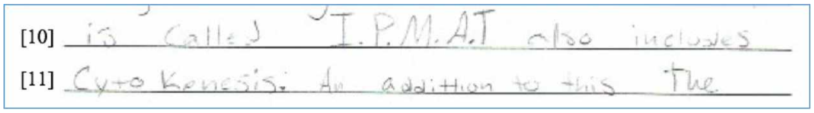
[1] Mitosis is known as cell reproduction repeating the
[2] cycle of IPMAT. In addition to this cytokenesis is
[3] involved within IPMAT. The stages of IPMAT are
[4] Interphase, Prophase, Metaphase, Anaphase, and Telophase.

Writing excerpt 4.11: (Tom:D:L1-4) Tommie's Session 5 writing, "… cytokenisis (sic) is involved within IPMAT."

Teacher reflections and interpretations—Group 2.

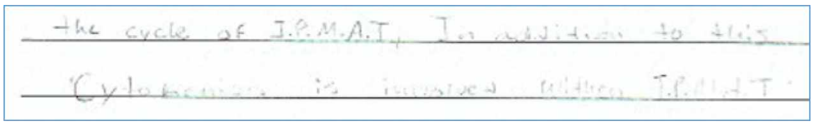
Before joining Tommie, Helen's work was unique and individualized in Stages A and B. She was essentially working alone within a more passive table group during those prior sessions. Writing excerpt 4.12 (a-b) (next page) reveals some of that persistent independence. It was in that session that Helen had come to the conclusion that "IPMAT also includes cytokinesis" which disagrees with all of the resource materials at her disposal. She has doggedly maintained that opinion since then. Writing excerpt 4.12 shows how Helen has modified her wording from Stage A (Writing excerpt 4.12 (a)) to Stage D (Writing excerpt 4.12 (b)). What was first *"IPMAT also includes cytokinesis"* has been reworked to state that *"cytokinesis is involved within IPMAT."* Her initial erroneous interpretation remains, but the phrasing has evolved.

Helen has misconstrued the facts and those erroneous interpretations have persisted in the face of several friendly attempts to take on a more correct interpretation.


[10] is called I.P.M.A.T also includes
[11] Cyto Kenesis: In addition to this The

(Typed: I.P.M.A.T also includes cytokinesis.)

a) (Hel:A:L10-11) Helen's previous connection of mitosis (IPMAT) to cytokinesis.

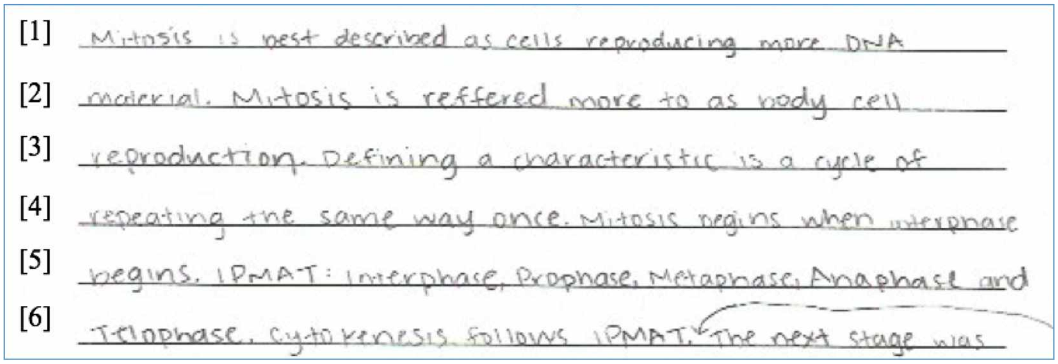

the cycle of I.P.M.A.T, In addition to this
Cytokenisis is involved within I.P.M.A.T

(Typed: In addition to this cytokinesis is included within I.P.M.A.T.)

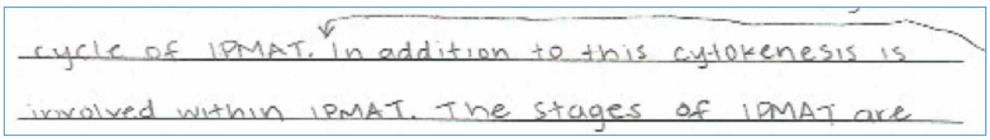
b) (Hel:D:L2-3) Amending "also includes" to "is involved within" IPMAT.

Writing excerpt 4.12 (a-b): Helen's minor text adjustments from Stage A to D; a) (Hel:A:L10-11) Helen's previous connection of mitosis (IPMAT) to cytokinesis; b) (Hel:D:L2-3) Amending "also includes" to "is involved within" IPMAT.

Tommie's Session 5 writing smooths her Session 4 writing as she works with the uncomfortable connection of IPMAT to cytokinesis (Writing excerpt 4.13 (a-b)), next page. Previously, in Stage C she had written that *"cytokinesis follows IPMAT"* (Writing excerpt 4.13.a) a statement she knows to be correct. During Stage D Tommie has reversed and reconsidered her position, following Helen to adopt "in addition to this involves cytokinesis" and folds cytokinesis into IPMAT stating, *"cytokinesis is involved within IPMAT"* (Writing excerpt 4.13.b).


[1] Mitosis is best described as cells reproducing more DNA
[2] material. Mitosis is reffered more to as body cell
[3] reproduction. Defining a characteristic is a cycle of
[4] repeating the same way once. Mitosis begins when interphase
[5] begins. IPMAT: interphase, Prophase, Metaphase, Anaphase and
[6] Telophase. Cytokenesis follows IPMAT. The next stage was

a) (Tom:C:L1-6) Stage C's writing,"cytokenesis follows IPMAT.


cycle of IPMAT. In addition to this cytokenesis is
involved within IPMAT. The stages of IPMAT are

b) (Tom:D:L2-3) Tommie capitulates in Stage D, radically amending her phrasing from "follows IPMAT" to "is involved within IPMAT."

Writing excerpt 4.13 (a-b): Comparing Tommie's Stage C and D mitosis-cytokinesis perspectives; a) (Tom:C:L1-6) Stage C's writing,"cytokenesis (sic) follows IPMAT; b) (Tom:D:L2-3) Tommie capitulates in Stage D, radically amending her phrasing from "follows IPMAT" to "is involved within IPMAT."

The story of Group Two is also one of confident competence. Each student participated in the dialogue and useful, collaborative writing was produced. Having not conversed before these sessions, Helen and Tommie grew a relationship based on independent contributions and constant *teaming*. As they got to know each other and the TAL better they were able to work together to build a cogent, descriptive, paragraph that explained fundamental scientific relationships. Granted, a key component of their final consensus was flawed.

As they worked I observed that Group 2 is becoming "more frequently and more intensely collaborative" (TAR Journal, 12APR18). Their struggle was reengaging their scientific discourse after bouncing out on tangents. As Helen and Tommie worked together they got more excited. They got caught up in the conversation and frequently drifted off topic. They naturally made inferences beyond the topic, but returned to the assigned conversation on their own. The group seemed open to discussing their opinions and ultimately, after rehashing their writing, converged on Helen's incorrect assumption. The science writer's workshop is intended to incorporate such opportunities for student wonderings within literacy-based activities.

These students' natural connections and extensions beyond their dialogue support my understanding of the power of literacy/ workshop-based instruction within content-specific science instruction. The groups were very clear in their representation of the process of mitosis. It was interesting to notice how in Group 1's final writings they were divided sharply between the two opinions, whether cytokinesis "is" or "is not" a part of mitosis. It was also interesting to observe that as Group 2 finished their work, Helen's persistent belief pulled Tommie to the misconception that cytokinesis was a part of mitosis. This one misstep seemed to occur at each table for slightly different reasons.

Patterns in the Dialogue

Focused recoding of the action-based initial categories was done line by line in each LRE, a somewhat brief snippet of dialogue that includes a specific learning event or languaging occurrence which can then be evaluated in context. The focused coding pointed to three recurrent categories or patterns: teaming, disagreeing, and going beyond the content.

- *Teaming*. Small groups worked closely together, conversing to solve their meaning-making and summary writing challenges.
- *Going beyond the content*. As students practiced with the TAL they made deeper connections to their content knowledge and to their wider world.
- *Disagreeing*. During collaborative activities there were differences of opinion and differences in motivation that caused strife within each small group.

The narratives of each of these unique table groups illustrate that, in general, students began the workshop by thinking and writing independently. As the process moved forward, they began working interdependently, sometimes helping one another and coming to depend on their group members. Finally, their writing products suggest that toward the end of the workshop their responses became more similar—even sometimes converging on identical responses, even allowing incorporation of incorrect explanations, explanations with which Harry and Tommie both disagreed.

Subsequent to Stage D, as we were wrapping up the unit, three students (Helen, Matt, and Tommie) were able to compete the all components of the collaborative, meiosis writing assignment, Stage E: Enrichment (meiosis). Several factors—school-related absences, cultural activities, mandatory English fluency testing—interacted to cause that assignment to be completed independently with few, chance collaborative actions occurring during those days. My journal notes state that "Table 2 was very quiet as they wrote their comparisons together" (TAR Journal, 27APR18). Student Stage E writings are not attached, for lack of dialogic interaction, and there is no analysis of Stage E writings.

The specific focus of this section is to investigate patterns of activity in how middle school students engage in content learning and in the use of TAL during the science writer's workshop. In this section I will define, explain, and provide examples of three emergent patterns in student dialogue: teaming, disagreeing, and connecting/extending TAL beyond the text.

Teaming.

When small groups worked together, collaborating to answer a question they were *teaming*. While Group 1 struggled to maintain a teaming posture, Group 2 was naturally teaming during this science writer's workshop. Generally speaking, Group 2 seemed to be teaming more consistently than Group 1. Teaming was also evidenced by busy, chattering engagement in the task. Teamers were animated, using gestures and facial expressions to communicate and build on each other's contributions. Teamers often focused on word choice. For example, Group 1 (Transcript excerpt 4.15) worked together through proper pronunciation of a new word "interphase" (also mentioned above in the Group 1 narrative).

Transcript excerpt 4.15: *Coded Patterns of Teaming Interaction (G1:S2a:LRE#2)*

[1] M: Okay. Mitosis starts when interface begins.
[2] S: Okay. Mitosis begins when the interface ~begins(?)
[3] M: No, the interphase cycle begins. [S: yeah]
[4] H: Mito-sis begins when interphase begins <all LLL>
[5] S: That doesn't sound right. Let's change that <chuckle>.
[6] [[S: Mitosis...
[7] [[H: IPMAT, cyto-ki-nesis follows IPMAT.]
Note: Emphasis mine to point out change in diction.

In much the same way, Group 2 teamed as they deliberated about whether to use the word "including" or "in addition to this" (Transcript excerpt 4.16).

Transcript excerpt 4.16: *Coded Patterns of Teaming Interaction (G2:S5a:LRE#1)*

[1] TR: Hm-mm a word for including?
[2] Helen: "In addition to this involves cytokinesis."
[3] Tommy: Yeah.
[4] H: Does it hear good for the sentence?
[5] T: In addition to this, cytokinesis
[6] [TR: A longer word for what? Including?]

[7] H: I forgot what I said.
[8] T: ME tOO!
[9] [[H&T: <LLL> In addition to this~]]
[10] H: Man, I had good word for including!
[11] T: Involves!
[12] H: Yah, involves.

Small groups worked diligently and uninterrupted whenever and as long as I could facilitate that focus. Group 1 struggled more to stay civil and on task than did Group 2, though they too occasionally needed a reminder to return to the assigned discussion. The written products of the teaming efforts showed a notable personal investment and were substantially more detailed than the writings during the more argumentative periods. Teaming outputs were more likely to be somewhat unique and thoughtful whereas non-teaming statements were more often brief and fragmented, or transcription error-filled copies of one another. Listening to them work, I noticed that teamers were actively engaged in building strong, well-articulated sentences and making meaning of the process of mitosis. Conversely, non-teaming comments seemed to be focused on getting to the end of the assignment.

I first recognized teaming was a pattern in Group 1 and Group 2 interactions during the data analysis, my coding/recoding process. I realized then that students had also been "teaming" in the instructional sessions prior to the beginning of the workshop. Teaming groups seemed to make more connections, easier, than non-teaming groups. My students sometimes struggled with the complexity of the extended, multi-step, abstract explanation of the process of mitosis and the use of TAL. Discussing mitosis using TAL isn't something that students are able to grasp easily until they have internalized the language. Without practice, this content and the enrichment assignment comparing the two similar processes of mitosis and meiosis, is challenging for anyone.

Teamers used a variety of resources. Oral and written language were directly involved in the task and included class notes and memory tools from previous instruction, and each other. Teamers accessed visual images when some looked to the web-based instructional articles or hardbound reference texts, the sketches they had drawn, or in-the-moment gestural representations. Sometimes singing or humming was heard in the room during teaming, specifically Stu and Tommie, Group 1 and Group 2, respectively.

On two occasions teamers led themselves to incorrect conclusions. The groups either convinced themselves that erroneous information was true, as in 'attaching cytokinesis as a step of mitosis,' or in the addition of the term 'cells' in the intermediate stages of meiosis. These erroneous thoughts were uttered by a group leader and gained acceptance going forward. The discussion of whether mitosis (or IPMAT), was connected to cytokinesis received much attention in both groups. In future iterations of this science writer's workshop I may involve a larger, tactile cell cycle puzzle or activity to cement the mitosis, cytokinesis relationship more intentionally, in the pre-instruction sessions.

The analysis focuses on five of the students, but my journal also records observations of the whole class of students. Not all students in the room engaged in teaming. Some days, students grew tired more quickly and lost focus. Loss of focus seemed to lead to disengagement, lower cognitive effort, and more off-topic conversation. Though not ideal, disengagement is not unusual, especially when the content is challenging. Participants were typical students and were not constantly engaged in collaboration during this science writer's workshop. A few participants found themselves put off or over-tasked by the reading requirement and the necessary face-to-face engagement. All participants had stronger days and more exhausted days. Some days were more challenging when students would arrive to class already exhausted.

During class sessions and at end of class wrap-up, the recordings showed that teaming dyads appeared to be more light-hearted and generally positive about the day, as they put away their things there was a tangible sense of togetherness and teamwork. When small groups were teaming some reported "that time flew by" and they accomplished more. By promoting busy, on-task behavior teaming may inhibit unwanted, distracted behavior through the day.

Going beyond the content.

Two focused codes make up this category, *connecting TAL beyond the text* (to prior learning), and *extending beyond the targeted content*. These codes show me evidence of cognitive connections and of a student's deepening links to the content, of cognitive engagement.

Connecting stories/experiences to the content seems to enhance internalization of TAL. The internalization of TAL is a time intensive process that is supported by dialogue like that in this science writer's workshop. The science writer's workshop is a process of building or deepening connections. Through the workshop process, students can begin using language across the curriculum and in their daily lives. Connecting TAL beyond the text and to prior learning is evidenced by recognition of language (words) that are similar, or strike a similar note when spoken or written, invoking a memory. Transcript excerpt 4.17 shows Tommie's connection to 'impact' a homophonic term to IPMAT. It also shows Helen's connection of cytoplasm to cytoclops and then to cytokinesis as she searches for the words in Line 5. Such homophonic connections may become bridges to TAL until terminology is more completely internalized.

Transcript excerpt 4.17: *Coded Patterns of Connecting (G2:S4:LRE#2)*

[1] T: I almost write impact.
[2] H: Including cy-cyc-cccych-rr-kinesis? [T: Oh!?]
[3] H: Including.
[4] T: Cy-cyt-ccc~ wait I know <page turning> cytokinesis.
[5] H: Cyto. Cyclo. Cyclops.
[6] ~~H: Can you put thick skulls in a boy or girl got mixed up bones?~~
[7] T: . . . {let's add} cy-to-plasm.
[8] H: plasm. Eww, plasm <haha>.
<brief writing recess from speaking>

[9]	H: Mmm. Including cytoclops.	Wait.		yeah.
[10]	T:		cyt~	Cytokinesis

In Transcript excerpt 4.18, Group 2 sorts out the spelling of 'cytokinesis' and Helen connects the TAL to a memory of Ken dolls. Perhaps the thought of 'that word like Ken doll…' will be a trigger for cyto-KEN-isis, the process of dividing mature cells, at a later time.

When transitioning between activities or when wrapping up the class period students occasionally extend beyond the content, using free association of words from their life with the content or asking the random, tangential question. When they do this, students are extending their TAL and content concepts beyond the text into deeper or broader somehow related, scientific connections.

Transcript excerpt 4.18: *Coded Patterns of Connecting (G2:S5:LRE#4)*

[1] T: How'd you spell cytokinesis?
[[Wait.
[2] H: I don't know I won't guess.
[[Wait, wait.

<both vigorously page turning, and LLL>

[3] T: It's right(^) here(^). C-Y-T-O-KEN-E-SIS.
[4] T: Okay I spelled it right.
[5] H: I spell cy, why, tea, oh, kay.
[6] T: Cy why? <LLL>
[7] H: C Y T O K I N E S S, ah'S. I mean S I S.
[8] T: It's Ken. K E N.
[9] H: Ken
[10] H: When I was small we didn't have any Ken dolls, we had to make the girls as men.
[11] T: What?

When students make such connections in the science classroom they are inviting one another into a new conversation, a meeting-after-the-meeting, a time of unstructured thought, idea bouncing, and connection building. The questions and wonderings below are excerpts from Helen and Tommie's conversations in their last Stage D sessions. They were uttered in transition between thoughts, during the sessions, or at the end of class as we were preparing to head to lunch.

- "Is there such a thing as gay cells?"
- "Is the stages of sex the stages of the baby?"
- Oh:::h-oh. Stages of sex cells?
- "Hey look, hmmm …does? Mitosis is a continuous cycle! <eyes wide>"

Extending events such as these are exciting moments of scientific engagement that can spread the scientific conversation to others and change the course of the classroom discussion to a more engaging, student-centered one. In the past I have used a two-minute warning game to engage students' connections with the content material. Such manipulated activities seemed somehow inappropriate with this age group and engaging only the willing. As teacher I wonder how to better facilitate these meetings-after-the-meeting. I am curious whether they should be allowed to remain freeform conversations or be managed or prodded along in some manner.

Disagreeing.

Three behavioral patterns appearing in the data were coded as *disagreeing* behaviors when students were unable to collaborate to agree on how best to proceed: banging heads, negating each other, and negotiating talk. On some occasions disagreement about a detail sparked deeper conversation and appeared to contribute to agreement in students' writing.

Not all collaboration is useful, on-topic interaction. Disagreements and differences of opinion take place routinely when embracing a scientific, growth mindset. Occasionally students were seen to be *banging heads*, with overt behavior contributing to strife within the group.

During the science writer's workshop, I based student grades on participation in the process, whether solo or as a part of their group. All participating group members received the same grade with intent to instill an extrinsic motivator for participation and goal-setting in the groups. Possibly as a result, off-task behaviors in motivated groups occasionally contributed to banging heads. Small groups operating with multiple leaders were more prone to banging heads about staying on task to get a good grade for the day's work. In groups with unbalanced motivation, e.g. highly motivated and less motivated students, frustration occasionally occurred on the part of the motivated while guiding the unmotivated to make useful progress and vice versa. Transcript excerpt 4.19 is an example of a disagreement (banging heads) which seemed to be generated by differing levels of motivation. Banging heads also occurred when group members took a position, neither one letting go of a statement they believed to be factual. I observed that disagreements over scientific connections seemed more common and that differences in language choices were more negotiable.

Transcript excerpt 4.19: *Coded Patterns of Banging Heads (G1:S4:LRE#2)*

[1] H: Will you let me copy?
[2] S: No, not copy, jeez!
[3] S: Hmmm <reading Harry's paper> {??}phase, anaphase, prophase, interphase, there's metaphase, IPMAT. You need anaphase now. The fifth and final cell is anaphase.
[4] M: It's not final, uh cytokinesis.
[5] S: No(^), cytokinesis is a different thing. Cytokinesis isn't part.
[6] S: Last one.
[7] M: Cytokinesis is part of mitosis. Part.
[8] H: <writing out loud> Ana-phase.
[9] S: <in condescending cartoon voice> Anaphase is the 1 - 2 - 3 - 4th one. The 5th one is telophase. The 6th one is cytokinesis.
[10] H: <to Matt> He told me to write "the fifth and final cell."
[11]
[12] H: You too Matt, mistake!
[13] M: I-I never did that.

Negating was another observed behavior; disagreeing by ignoring of the other student's input. Negating each other entails not recognizing or taking in the other's perspective or opinion. Unlike banging heads, in negating situations groups seemed to be agreeing-to-disagree and move forward, or just move forward without regard for the other's thoughts.

In their more collaborative moments small groups tended to operate easily, co-constructing effortlessly, but more confident thinkers in both groups were prone to negating one another when reaching an impasse. As Matt and Stu struggle to collaborate, Transcript excerpt 4.20 (Line 10) shows Matt notices Stu's disregard of his efforts. Transcript excerpt 4.21, shows that Helen and Tommie disagreeing and moved on to independently write their version of the proper response (Line 6). Yellow highlights show argumentative and negating responses.

Transcript excerpt 4.20: *Coded Patterns of Negating (G1:S2:LRE#7)*

[1]	S: Look. Mitosis is best described as the division of cells.
[2]	M: oh yeah on this...
[3]	S: 'k. Um. Try read your second one, your second sentence.
[4]	M: I never wrote anything yet.
[5]	S: YOUR second sentence, Matt's second sentence!
[6]	S: 'k, write it down.
[7]	M: Mitosis is frequently referred~ to as body, cell, production
[8]	S: re-production!
[9]	M: Reproduction, there are you happy?
[10]	S: Yeah, let's do mine.

Transcript excerpt 4.21 shows that Helen and Tommie disagreed in the choice and moved on to independently write their version of the proper response (Line 6).

Transcript excerpt 4.21: *Coded Patterns of Negating (G2:S6:LRE#3)*

[1]	T: What should we say for the en-ding sen-tenc:::e? understate . . . um, wait.
[2]	H: Fish.
[3]	H: What should we say for the ending sentences to finish this, the paragraph?
[4]	T: We need to write this sentence~~ Mitosis is frequently referred to body cell reproduction.
[5]	H: Mmmm. Shouldn't we write that at the beginning?
[6]	T: I'm just going to write it at the end.

Often, disagreement produced useful, *negotiating talk*. Negotiating talk is conversation that—through the disagreed upon concept—brought about listening to others' perspective or opinion, clarifying one's own opinion, and generally moving the conversation forward. Transcript excerpt 4.22 shows disagreement producing negotiating talk in Group 1. Key points here are (Line 3) their self-repair of "interphase" and their agreement to revise their writing on Line 5. Revision is not common in my students' in their science writing. The extra, programed, writing time may have given time to consider such TAL and edits.

Transcript excerpt 4.22: *Coded Patterns of Negotiating Talk (G1:S2:LRE#2)*

[1] M: Okay. Mitosis starts when interface begins.
[2] S: Okay. Mitosis begins when the interface ~begins(?)
[3] M: No, the interphase cycle begins. [S: yeah]
[4] H: Mito-sis begins when interphase begins <all LLL>
[5] S: That doesn't sound right. Let's change that <chuckle>.

[6] [[S: Mitosis...
[7] [[H: IPMAT, cyto-ki-nesis follows IPMAT.]
<45 seconds of jumbled, confused dialogue breaks out as Group 1 sorts out what they are hearing and reading.>

(Note: Emphasis mine to point out change in diction.)

Similarly Group 2 in Transcript excerpt 4.23, we see Helen demonstrating negotiating talk as she is rhetorically disagreeing with herself in Lines 1-3. Then, in Lines 6-9 the girls are further disagreeing as they negotiate their understanding of mitosis and move their conversation forward.

Transcript excerpt 4.23: *Coded Patterns of Negotiating Talk (G2:S4:LRE#2)*

[1]	H: Mitosis' known as cell reproduction. What~? <rhetorical>
[2]	H (?): °Mitosis is known as cell repro-duc-tion~ repeating.°
[3]	H: Mitosis' known as cell reproduction repeating~ every cycle? No, not every cycle. Repeating it. . .
[4]	T: Repeating~ it-itself.
[5]	T: No. haha. Mitosis isknownascell reproduction repeating~~ [H: it] Wait. Repeating, um~~ the cycle?
[6]	H: The cycle of It.
[7]	T: I forgot what I just said.
[8]	T: Repeating what?
[9]	H: IPMAT. Repeating the cycle of IPMAT.

I believe that working through disagreement is important. Though there were verbal disagreements, the safety of the students was never overtly at risk in these discussions. No student reported feeling ambushed or overwrought during any of the writer's workshop sessions. Disagreeing seemed to be both beneficial and detrimental to the conversation, dependent on social factors. Though disagreements focused on details of TAL or on details of the content, TAL seemed to be the most heavily debated. The science writer's workshop sessions prompted me to wonder how much disagreement is helpful and at what point intervention is warranted in the interest of moving forward academically and maintaining good order and discipline. It also made me wonder what the teacher's role might be in helping students to learn to engage in negotiating talk.

Summary of Findings: TALA is More than Words—It is a Dialogic Process

Analysis of the student dialogue and written artifacts of this TAR has led me to confidently assert that middle school students more excitedly engage in content learning and the use of TAL through co-constructive student dialogue and writing. Using TAL with one another for a concrete purpose and extending the language into their lives the scientific concepts appear to become more real to these students. The science writer's workshop is one way to frame those kinds of experiences as students learn scientific concepts.

The content learning, the dialogic interaction, and the written words are inextricably woven together and the progress of one cannot be separated from the other. As my students pull the words from their minds, feel the spoken words in their mouths, and write the words with their pencils they seem to build competence and confidence with the concepts and their new discourse—Technical Academic Language.

Chapter 5: Conclusions and Implications

The Evolution of a Science Literacy Coach

As I moved from practical scientific investigator to science educator I taught the science of my lab-coated high school mentors (Doc Schwede, my physics teacher) and of my earlier career—a science of numbers, formulae, processes, and scientific report writing. That method may have been adequate for mainstream students on an Advanced Placement science track but it did not serve the typical monolingual student. Emergent bilingual (EB) students whose language experiences are different from the mainstream English used in textbooks, face challenges in trying to make sense of the typical instruction that features wide yet shallow coverage of challenging content.

In my early teaching days when asked to teach to issues of literacy I might have responded that, "*I teach science*, not English, not reading, not writing. My students apply the reading and writing skills learned in English classes, from those teachers. Students apply their literacy practices learned elsewhere to science applications in their science coursework." Later, when teaching English language learners in international schools in the years to follow, I came to see the need to build language—both English language and scientific language—in my students. Today, through lessons learned in this teacher action research (TAR), I have the knowledge and tools (the workshop approach) to help students achieve more comprehensive technical academic language acquisition (TALA). Students' stronger technical academic language (TAL) will help them move away from test-and-forget science and toward engaged discussion of intrinsic scientific concepts.

Academic language is used in the writing of literary analyses and investigative science reports, in discussing the geography of Mongolia or to debate Earth's mathematical vulnerability to asteroid impact, and to discuss the violent history of vanilla ice cream. In this study, I focused on my students' use of technical academic language (TAL) in the context of a science writing workshop. These EB Grade 8 scientists worked together to synthesize an accurate summary of the biological processes of cellular reproduction.

More specifically, this study investigated the use of a writer's workshop approach to improve TALA among emerging bilingual students in my life science classroom. The focus was to provide opportunities for students to engage in content learning and in the use of TAL during a science writer's workshop. As Snow (2010) explained, students face challenges in a typical academic language-based classroom:

> [Without the] vocabulary being embedded in meaningful texts and . . . [used] in discussion, debate, and writing . . . it is unrealistic to expect all middle- or high-school students to become proficient producers of academic language. (p. 451)

Given that disciplinary educators are typically not trained in language instruction, EB students need more helpful TALA methods to coach them to success in their scientific writing. Along the path of my academic journey I learned more about Second Language Acquisition and literacy development. As I read and learned more I discovered the writer's workshop concept and sought to implement it in my science classroom.

In the instructional days leading up to the workshop these students were in the early stages of TAL mastery of these abstract cellular processes. They were not yet confident with the terms. The intent of the science writer's workshop was to give students the time and support necessary to learn both the content and the language of science. Scientifically speaking, one might say:

$$\text{Scientific language [TAL] + Scientific content} \xrightarrow[yields]{} \text{Process of language acquisition [TALA]}$$

Lessons Learned

Through this TAR, I learned four lessons about how to help my students build proficiency with TAL and also learn scientific content. Each lesson emphasizes the idea that meaning and TALA develop *in the process of applying* scientific content. The workshop is an invitation to apply TAL while more comfortably talking and writing about content. The process of learning is transferrable from our classroom to every facet of life and the process is the point. Here are four key takeaway(s) that I might tell another teacher:

- Focus on process over product.
- TALA is more than just the words—It is the dialogic process.
- Collaborative dialogue builds confidence in the scientific writing process.
- Process choices are active decisions.

Focus on process over product.

A correct answer is important of course, this is the goal of the scientific process, but wrong answers happen when practicing and learning. I believe that *how you got there*, how the answer given came to be the answer I chose, is really the point. Being able to look back and answer the questions: "How did I come to this conclusion?" or "Why did I think that?" allows for repeatability of that action or process. This is the power of a scientific process.

The point of science instruction is to model for students "how to" fearlessly do science. In this workshop process I have attempted to help students fearlessly attempt the processes of

- decoding new language for better comprehension,
- collaborating with others to solve a challenge,
- choosing a path to the most well thought out solution,
- returning to revisit unfinished thoughts,

- reconsidering uncertain solutions to the questions,
- writing what they have learned in scientific language.

These processes are not formulaic and this process of scientific thinking is not through cookie-cutter labs with perfect results to "show we did science." This writer's workshop process allowed—even encouraged—my students to dare to make mistakes in their talk and in their writing. They have had the freedom to make incorrect statements and to draw incorrect conclusions as a way to truly experience the power of collaboration in scientific thinking and writing. To me, this is what science education is all about. We grow scientists by opening doors to more effective communication and problem solving.

Rosenblatt's (1978) transactional model of literary response and Cope and Kalantzis' (2009) design cycle show me that the process of learning is transformative for the learner, forever changing the way they perceive every facet of the inquiry. As the student stands on the shoulders of their mentors they are able to extend beyond their mentors' perspectives. As discussed in Chapter 2, the student naturally reinterprets their prior learning through the lens of their present schema, and they begin to imagine the world in a different light themselves.

As my students studied mitosis and cellular processes from their assorted text materials and resources they formed a picture of what these abstract processes were. During the workshop these students brought their perceptions about the abstract process of mitosis to the group's conversation. Because each student understood the subtleties of mitosis a little differently they all needed to reconcile those differences going forward, thus the emphasis on the process of meaning making over product.

As students collaborated to resolve the differences in their understandings, which sociocultural researchers might call collaborative meaning making, they meta-cognitively reconsidered the meaning of their own words and the words of others. As teacher I have learned to plan for additional, collaborative, language-based student activities to allow them more time to internalize their TAL.

TALA: It is more than just the words—It is the dialogic process.

The second lesson that I learned from this TAR is that language-based activities are more than just time spent saying the words in contrived or rote circumstances. It is the authentic use of this new vocabulary and the act of mulling over thoughts and language with one another. Vygotsky (1978), Lantolf and Thorne (2007), Stromberg (2013), and others have stipulated the undeniable significance of TAL. Together they tell me that the practical use of language has given humanity the power to exceed the boundaries of our individual abilities and mediate the geographic and temporal limitations of knowledge. Language empowers us to affect change across the globe and over the millennia through sharing our thinking. As scientists we use our spoken and written language to influence the actions of others for better or worse. Zwiers and Crawford (2011) contended that learned participants in society must be able to rationalize those spoken and written words and apply the knowledge to our modern societal needs. Students must therefore master the unique genre of scientific language (Rainey & Moje, 2012) and the interpretation of scientific writing. They must be allowed to apply their languaging skills in context to achieve mastery of critical TAL. This is best done by integrating content with language instruction (Lyster, 2007).

As my students worked through our science writer's workshop they practiced their TAL through ungraded conversation/dialogue and through the writing, revising, and rewriting of their mitosis summaries. The writer's workshop-based strategy paid off in students' improved understanding of the language and in their understanding of the concepts as seen in their improved post-test scores. As teacher I need to press students to conduct more authentic TAL-based talk, more language revising, and more rewriting as a part of my daily content instruction. For example, as Group 1 held a discussion student contributions were considered and communally accepted or rejected as they dialogued together. Their process emphasized the act of getting it and thinking about the process. These students were making deeper connections to the language and to the content through co-constructive dialogue and enhancing their TALA through the conversational process. They were learning more than just the vocabulary words, they were learning when and why and how to use their TAL.

Collaborative dialogue builds confidence in the scientific writing process.

Third, I learned that students need to use their language with one another, making their case and hearing others' to think more clearly and deeply on their understanding of the content. Students teach themselves that they can find (learn/know) their way. Students across the world have been pushed to "do your own work" and "keep your eyes on your own paper" for a long while. Modern sociocultural theorists (Moll, 1992; Kimmerle et al., 2017; Storch, 2002; Zwiers, 2011) seem to agree that collaboration is a more effective method of achieving success. My predecessors and mentors followed the early classroom education models of independent effort and assessment of individual student's skills and occasionally applied group projects. In science, we learned academic aspects independently and did investigative lab work in pairs with little attention to language learning.

As my EB students work together in the science writer's workshop they are learning science concepts while folding in (performing) more language learning processes. This recursive, collaboration-focused, science writer's workshop process embraces individual funds of knowledge and supports deeper internalization of students' TAL. Content comprehension potential was increased while causing less student hardship along the way. The use of collaborative pairs (small groups) per Storch (2002) gives voice to individual's ideas in a collegial situation. The science writer's workshop gives students the chance to perform their TAL, and they "experience learning through performance that would otherwise not occur" (Swain & Lapkin, 1998, p. 123).

As I analyzed individual and small group dialogue and their writings, I found that neither aspect could be evaluated on its own. Each student's words, conversational interactions, and personal writings were part of an intertwined process of TALA. In completing their assignments, students' speaking, thinking, reading, writing, and talking were interwoven into a completely collaborative product. Each of these interconnected components contributed to the synthesized final product. For example, Group 2 frequently searched for the correct terminology as they bounced possibilities back and forth, working to find the proper word(s). They were struggling, writing, muttering, gesturing, and amending or appending each other's attempts until they found the needed term. As teacher I have learned that I need to nurture such small group discussion and interaction to let students lead themselves to deeper language and content learning. As students worked through the science writer's workshop in their conversational groups I noticed an increase in their confidence and a willingness to continue their work.

Process choices are active decisions.

Finally, I learned that students made active choices in their writing. In terms of how decisions were made, neither group appeared to resort to random choice, just guessing. In the end I observed some results similar to those of Johnston (2012), specifically in terms of groupthink, "pressure toward conformity" (p. 63), as the groups made a move to decide the direction of their writing. Right or wrong, the more articulate student or the more outspoken student in the group appeared to have more say in the path of the decisions. At some point as they deliberated in their co-constructive processes, Group 1 and Group 2 each struggled to commit to either "cytokinesis *follows* mitosis" or "cytokinesis *is a part of* mitosis." Each group had at least one member who spoke out for each option. As such, the process of how the decisions were made was interesting and may be worthy of further investigation. I learned that students may find their way to a solution based on their voices within the group dynamic, perhaps more so than their interpretation of the data in hand. They inevitably made a choice or choices, based on their dynamic dialogue.

Science Writer's Workshop

This science writer's workshop was effective in building deeper understanding of a meticulous natural phenomena, albeit not perfectly. The methodology of the science writer's workshop facilitated an ongoing scientific conversation between the writing process, the teacher, and the student, and between each student and the scientific writing process.

Through engaging students in the science writer's workshop I have engaged them in their own scientific conversations and reduced the obstacles to student success. I believe that students' useful struggle is appropriate, but minimizing the artificialities, diversions, and extraneous inputs of classroom life keeps the process more authentic. As teacher and as a scientist I am charged to facilitate these conversations of discovery. In conducting the science writer's workshop, constructive thoughts and ideas ran through my mind daily. I had more wonderings to consider, including:

Student grouping is a challenge:

- Dyads *may dialogue differently* than triads.
- Heterogeneous groups *may work differently* than homogeneous groups.

- Stronger students *may be more effective* peer-teachers.
- Dominant/Passive relationships *may lead to* bullies and voiceless students.
- Purposeful grouping *may lead to* fewer Dominant/Passive interactions.
    - Perhaps teachers can assign roles as in literature circles where each student has a set role, a part to play.

Student leaders are independent:

- Leaders *may focus on persistent beliefs* though an accurate answer is readily available.
- Spontaneous leaders *may be motivated by social (versus academic) agenda*.

This science writer's workshop was the most significant TAL writing assignment these eighth graders had ever undertaken. Our students have frequently engaged with various literary narratives in their English and history classes' coursework. TAL is equally meticulous writing with attention to a different kind of detail that is not the more familiar story prose. Though it was challenging, these EB Grade 8 students were generally comfortable and enjoyed collaborating in this scientific genre. Based on their struggles with previous, individual, short answer-style writing prompts in science class I had expected this writer's workshop would be challenging and somewhat uncomfortable for my students. Perhaps the structure and familiarity with filling in a straightforward, worksheet-style analysis tool or engaging with the increasing familiarity of repeated reading put these students somewhat at ease.

Though collaborative writing is engaging for our students they can tire quickly during long stretches of extensive writing. As I walked the room each day I found students were busy and, though not always strictly on-task, they were working and moving forward. They were seen to meander a bit between task activities and I was letting them be more casual, to mentally stretch a bit as they worked. Here in their first ever science writer's workshop students were caught up in the tedious detail of TAL; a different sort of detail than in other activities. The pursuit of scientific accuracy in their writings drew them further into the technical discussion.

Completing each stage was more time consuming than I had expected. Each stage required reading individually, reading together, discussing and considering the TAL, and co-constructing their written explanations. Students did tire a bit, but intent students were able to move forward at the pace of one stage about every two days. I believe that my students were experiencing genuine, useful struggle with the work and being diligent in their efforts. This dialogue-based TALA process simply took more time than I had imagined.

As they worked students made active choices in their writing. Conversations flowed within the social norms of each group and were skillfully influenced, dynamically pushed or pulled, toward one decision or the other. In the lulls between stretches of reading and writing, and at the end of class the meetings-after-the-meeting occurred. In those moments Group 2 would sometimes bounce words around, ask real or silly-but-real questions, and make outside connections in their off-topic chat. These relaxed side-chats gave students additional, ungraded thinking time with their TAL. An opportunity for unsupervised employment of valuable, "exploratory speech . . . to generate and explore ideas" (Smagorinsky, 2013, p. 194). Such opportunities are prime, student-led, meaning-making moments that allow for connection beyond the text and extension beyond the classroom. They helped build confidence and increase engagement with the TAL. I need to ensure that I program in a few minutes at the end of each class to allow for meeting after-the-meeting moments.

Implications for Future Research

This research project has been eye-opening to the power of building student confidence with TAL. The science writer's workshop has also supported TAL in the writings of some uneasy students who might otherwise have shied away from scientific discussions. During the analysis of these class sessions, students' collaborative dialogue, and written artifacts I have noticed a few themes for future investigation.

In the student dialogue:

- Do student read aloud experiences support *teaming* in secondary science students' dialogue? Individually reading and conversing out loud appears to support *teaming*.
- Does *teaming* contribute to more powerful dialogic debate and/or the co-construction of more convincing written paragraphs? *Teaming* appeared to lead to the making of more powerful points in the dialogue and co-construction of more convincing written paragraphs. This is a goal of the science writer's workshop.
- How does student *disagreement* contribute to the process of co-construction? *Disagreements* are common during co-construction. The more successful partnerships were able to work through disagreement to find agreeable solutions to the question or problem at hand. In Group 1 disagreement was more likely counterproductive, leading to hurt feelings through argumentative or dismissive behaviors.
- Is more intentional time for meetings-after-the-meeting valuable in assisting students to *extend beyond the content* and *connect TAL beyond the text*? Are those connections and extensions useful to them in their mastery of TAL and content? *Extension and connecting beyond the content* appear to occur naturally in transitional moments when minds were moving off topic and easing their cognitive load. It is worth building in a little unscheduled space for these meetings-after-the-meeting in our daily schedule.

For my teaching.

Teaching scientific concepts for application beyond the classroom is still my priority, but literacy first is a more helpful aim. The counterbalanced model Lyster (2007) of TAL woven into content instruction seems to be supported in the results of this TAR. Using new TAL imposes more intense dialogic requirements in the science writer's workshop. As a result, these students were exposed to higher than usual conversational expectations and higher cognitive loads. Since they have little experience in the use of TAL in reading, writing, and in discussions, this process took more time. Intentionally employing more TAL analysis in conversational activities while working with scientific concepts has been a useful strategy. Repeated use of the science writer's workshop strategy may bring student writing and reading skills up to grade level while moving ahead with content objectives, more quickly than other strategies.

In practice my students' technical comprehension and application of TAL in their reading, talk, and writing could be slow for lack of experience, but not for inability. I learned that these students can rise to this challenge, when supported appropriately. State testing, however, has suggested a deficit in these students since Grade 4 (State of Alaska, 2012). I believe that an appreciable portion of this low student performance is founded in the standardized testing process itself. You may recall the cartoon showing a group of different animals (a banana slug, chimpanzee, dolphin, eagle, giraffe, salamander, snake, etc.) in line to take an IQ test. The standardized test, "ring the bell at the top of this tree," is an inappropriate measure of every individual's cognitive ability. So it is true for every human student. A full critique of state testing is beyond the scope of this project, but the testing process produces and sustains low expectations. This TAR has illustrated that these students can work as scientists in the writing workshop. I have learned that time must be allowed for language use activities and for the support of EBs in content classes.

The aim of the science writer's workshop is investigation of the claim that more time to work with the language may increase student success. I believe my results support the hypothesis that students benefit from extra time to repeat, rethink, reread, and revise their writing when ingraining scientific concepts. For that reason, I must include more conversational TAL activity at each grade level to help build students' TAL literacy and build their comfort level, increasing exposure to TAL over time. The use of interactive student notebooks to catalogue key comprehension and composition tools of TAL will help to scaffold future writer's workshop activities. The science writer's workshop strategy will help to get students reading and discussing specific topics. The brief, focused, technical passages that my students read and wrote are similar to placement exam questions (word problems, writing prompts, or explanations). Working with these passages in context may also help build student success.

Language and literacy research.

One issue that is beyond the scope of this study but is suggested in the classroom, is that that male students tend toward working more quietly in class. Although the particular boys whose data is the focus in Chapter 4 were not quiet, a pattern I noticed across the whole group was that the boys seemed to find it difficult or uncomfortable to engage in dialogue during class.

As I explored this quiet nature of my male Yup'ik students during science class, Cathy Moses, an educator and Indigenous scholar, pointed out that the boys' quiet ways may just be a learned social habit. Moses stated,

> The boys' quiet ways may just be habits socially inherited (passed down) from their male mentors. When men are out hunting moose they don't group up and

> gab about what to do next. They use gestures, signals, and quiet words if they speak at all.

Sally Samson, Elementary Yup'ik educator, scholar, and traditional mother later added that:

> . . . our men and boys might also be quite out of respect. Yup'ik people have this belief that there is a connection between humans, land, and spirituality. We are taught early on to be aware of how we treat others, the animals, and the land.

Following that line of thinking, the silent nature of male high school students could be related to cultural Yup'ik gender roles as quiet hunters and good listeners. Alternatively, these traditionally quiet gender roles could be driving neo-traditional Yup'ik culture not by necessity, but out of habit. Perhaps this is why I have boys that find it difficult or uncomfortable to engage in dialogue during class. There could be other reasons for these students' silent ways that would be honored with future investigation.

Related to that, another issue for future investigation is the teacher's role in encouraging classroom dialogue. We've been taught teacher proximity as a classroom management strategy. I have found, however, that my too frequent presence could be providing an "ask teacher effect," consequently inhibiting valuable student conversation (struggle) per Zwiers and Crawford (2011). During the science writer's workshop, I noted that student groups' conversation would sometimes change as I neared. Sometimes students would get on task, other times they would slow or stop their conversation to ask for my opinion or advice. To allow for natural conversation flow during our co-constructive meaning making sessions I often had to busy myself taking notes just outside the student's area of concern. I believe that further study into the effects of teacher proximity adds value to the discussion of co-constructive student dialogue in science education.

Implications for TAR

As a long-time practitioner of the sciences, I have tried to keep myself open to new perspectives and new methods to bring science to the more modern student. This TAR is an extension of that ongoing process. Looking back at this TAR, I would apply some specific considerations for future TAR projects:

- Begin *more detailed note-keeping, earlier* in the research.
- *Conduct research earlier* in the school's academic/athletics calendar.
- *Plan more time* for practical language and content learning.

Though I wrote many memos detailing the learning process and facets of constructivist grounded theory in the way of Charmaz (2014, p. 162) and extensively documented the targeted Stages C and D, equally detailed student data collection in the earlier stages would have provided additional insight to my analysis.

This TAR was conducted in the Spring Semester which proved to have too many interruptions. Conducting the data collection in October/November may have provided a more coherent flow and daily schedule for my student participants.

Though I "allowed" additional time for students' dialogic activities I was forced to shave down the data collection to one cycle of the science writer's workshop, without a second iteration to compare and contrast findings. Knowing now that the discussion, writing, revising process is more time consuming, I would schedule an additional two days per collaborative writing stage. This would allow time for a second evaluation cycle of the TAR's target concept in a different science topic during the Spring Semester. That second cycle would provide corroboration of initial findings in the first cycle thereby deepening my science writer's workshop analysis.

Conclusion

In the beginning I was an applier of science, then a teacher/leader of young scientists studying the technicalities of scientific process, and I am still. Today I am teaching EB learners who are attempting to master both language and scientific relationships. I have learned that these particular modern students perceive their academic needs differently than do we their elder educators. As a result of becoming more aware myself, I have become a student of the reading and writing process and a student language coach. I have become a science literacy coach.

TAL may have been more common parlance in the lives of my peer group than in the lives of my Yup'ik students, but it was difficult then too. TAL pushed me, as a sophomore, away from biology until I found a motivation to master the language years later. The language was a gateway to the scientific concepts. Here in this village today, the same TAL is a barrier to students' learning of scientific concepts. The unfamiliar language may be causing my EB students to disengage to avoid the embarrassment and shame of not knowing how.

Having watched students struggle helplessly amongst words that have no root in their culture or in their daily language I have engaged in a more TAL-based presentation of science instruction. I have begun more intentionally integrating TALA and science content learning. I have hoped to build a process bridge: a method that allows students to use *what they knew before* and what they've learned to attempt to explain *what they think they know now*, and fearlessly engage in doing science. The science writer's workshop has allowed these students to participate in scientific relationships by

- focusing on the scientific process, not the product,
- conversing in the TAL of science and making that language their own,
- actively engaging and writing about what they think they know,

    - discussing whether . . .,
    - choosing between . . .,
    - disagreeing about . . .,
    - deciding how to . . ., and
- revising their writing to produce a mutually understood and agreeable product.

This process has borne good fruit. An unidentified thinker once said that *the mind, once stretched, never returns to its original shape*. The science writer's workshop is intended to be a mechanism for stretching the mind. Though the aim of typical science instruction might be a perfect product or an ideal scientific solution, my goal—and the goal of the science writer's workshop—is the stretching of the mind through co-constructive dialogue. And that is about more than just the words.

References

Burke, P. (2009). *The elements of inquiry*. USA: Pyrezak Publishing.

Casher, C., & Stotler, D. (2015). The four resources model: Critical literacy in the time of the common core. *Michigan Reading Journal*. *48*(3), 19-27.

Charmaz, K. (2014). *Constructing grounded theory*. (2nd ed.). Thousand Oaks, CA: SAGE

Cope, B., & Kalantzis, M. (2009). "Multiliteracies": New literacies, new learning, *Pedagogies: An International Journal*, *4*, 164-195.

Dewey, J. (1907). *The school and society: Being three lectures*. Chicago, IL: University of Chicago Press.

Dyson, A. H. (2015). The search for inclusion: Deficit discourse and the erasure of childhoods *Language Arts*, *92*(3), 199-207.

Fang, Z., & Coatoam, S. (2013). Disciplinary literacy: What you want to know about it. *Journal of Adolescent & Adult Literacy, 56*(8), 627-632.

Feliú-Mójer, M. (2015). Effective communication, better science. *Scientific American, Guest BLOG*. 24 February, 2015. Retrieved from https://blogs.scientificamerican.com/guest-blog/effective-communication-better-science/.

Freire, P. (1970). *Pedagogy of the oppressed*. NY: Continuum Publishing.

Guba, E. G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology, 29*(2), 75-91.

Johnston, P. H. (2012). *Opening minds: Using language to change lives*. Portland, ME: Stenhouse.

Kalantzis, M., & Cope, B. (2008). Language education and multiliteracies. In S. May & N. H. Hornberger (Eds.), *Encyclopedia of language and education, (Volume 1: Language policy and political issues in education)* (2nd ed.) (pp. 195-211). Berlin, Germany: Springer.

Kimmerle, J., Moskaliuk, J., Brendle, D., & Cress, U. (2017). All in good time: Knowledge introduction, restructuring, and development of shared opinions as different stages in collaborative writing. *International Journal of Computer-Supported Collaborative Learning*, *12*, 195-213.

Lantolf, J. P., & Thorne, S. L. (2007). Sociocultural theory and second language learning. In B. VanPatten, and J. Williams, Eds., *Theories in second language scquisition: An introduction* (pp. 197-221). Mahwah, NJ: Lawrence Erlbaum.

Lyster, R. (2007). *Learning and teaching languages through content: A counterbalanced approach.* Philadelphia, PA: John Benjamins North America.

Mahn, H. (2012). Vygotsky's analysis of children's meaning making processes. *IJEP– International Journal of Educational Psychology, 1*(2), 100-126.

Martin, K. (2008). The intersection of Aboriginal knowledges, Aboriginal literacies, and new learning pedagogy for Aboriginal students. In A. Healy, Ed., *Multiliteracies and Diversity in Education: New pedagogies for expanding landscapes* (pp. 58-81). NY: Oxford University Press.

McKechnie, L. (2016). *Plotting the reading experience: Theory/practice/politics.* Retrieved from *https://ebookcentral-proquest-com.proxy.library.uaf.edu.*

Mills, G. (2018). *Action research: A guide for the teacher researcher*. NY: Pearson.

Moje, E. (2007). Developing socially just subject-matter instruction: A review of the literature on disciplinary literacy teaching. *Review of Research in Education*, *31*, 1-44.

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice*, *31*(2), 133-137.

Morris, L. (2012). *Awakening brilliance in the writer's workshop: Using notebooks, mentor texts, and the writing process*. NY: Routledge.

New London Group. (1996). *A pedagogy of multiliteracies: Designing social futures*. Harvard Educational Review, *66*, 60-92.

Newsela. (2017). The facts about cells. *ThoughtCo.com*, adapted by Newsela staff. Retrieved from http://www.Newsela.com .

Patterson, L., & Wickstrom, C. (2017). How much support is enough?: 3 tools to help us know when to step in and when to back off. *The Learning Professional, 38*(1), 48-53.

Rainey, E., & Moje, E. B. (2012). Building insider knowledge: Teaching students to read, write, and think within ELA and across the disciplines. *English Education*, *45*(1), 71-90.

Rosenblatt, L. (1978). *The reader, the text, the poem*. Carbondale, IL: Southern Illinois University.

Shanahan, T. (2017). Disciplinary literacy in science. *Shanahan on Literacy* website. Retrieved from https://shanahanonliteracy.com/publications/disciplinary-literacy-in-science/ .

Shanahan, T., & Shanahan, C. (2008). Teaching disciplinary literacy to adolescents: Rethinking content-area literacy. *Harvard Educational Review, 78*(1), 40-59.

Shanahan, T., & Shanahan, C. (2012). What is disciplinary literacy and why does it matter? *Topics in Language Disorders, 32*(1), 7-18.

Snow, C. (2010). Academic language and the challenge of reading for learning about science. *Science, 328*(5977), 450-452.

Smagorinski, P. (2013). What does Vygotsky provide for the 21st century language arts teacher? *Language Arts, 90*(3), 192-204.

State of Alaska, Department of Workforce Development. (2012). *Alaska Career Ready Factsheet.* Retrieved from https://www.achieve.org/files/AlaskaCCR_FactSheet-Sept2012.pdf/ .

State of Alaska, Department of Education and Early Development. (2012). Alaska English/language arts and mathematics standards: Grades 6-12 reading. Retrieved from https://education.alaska.gov/akstandards/standards/AKStandards_ELAandMath_080812.pdf/. (pp. 2-3).

Storch, N. (2002). Patterns of interaction in ESL pair work. *Language Learning*, *52*, 119-158.

Stromberg, J. (2013). What is the Anthropocene and are we in it? *Smithsonian Magazine*. Retrieved from https://www.smithsonianmag.com/science-nature/what-is-the-anthropocene-and-are-we-in-it-164801414/.

Swain, M. (2000). The output hypothesis and beyond: Mediating acquisition through collaborative dialogue. In J. Lantolf (Ed.), *Sociocultural approaches to second language research* (pp. 97–115). Oxford: Oxford University Press.

Swain, M., Kinnear, P., & Steinman, L. (2011). *Sociocultural theory in second language education. An introduction through narratives.* Tonawanda, NY: Multilingual Matters.

Swain, M. & Lapkin, S. (1998). Interaction and second language learning: Two adolescent French immersion students working together: *The Modern Language Journal, 82*, 320-337.

Tobin, M. J. (2003). April 25, 1953: Three papers, three lessons. *American Journal of Respiratory and Critical Care Medicine*, *167*(8), 1047-1049. Retrieved from https://www.atsjournals.org/doi/full/10.1164/rccm.2302011/.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* M. Cole, V. John-Steiner, S. Scribner, E. Souberman (Eds.). Cambridge, MA: Harvard University Press.

Wells, G. (2007). Semiotic mediation, dialogue and the construction of knowledge. *Human Development*, *50*, 244–274.

Williams, J. (1989). *Style: Ten lessons in clarity and grace.* (3rd ed.). Glenview, IL: Scott Foresman.

Wilson, S. (2008). *Research is ceremony: Indigenous research methods.* Winnipeg, Canada: Fernwood Publishing.

Zwiers, J., & Crawford, M. (2011). *Academic conversations*. Portland, ME: Stenhouse.

Appendix A: IRB Authorization

(907) 474-7800
(907) 474-5444 fax
uaf-irb@alaska.edu
www.uaf.edu/irb

Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

November 21, 2017

To:	Leslie Patterson Principal Investigator
From:	University of Alaska Fairbanks IRB
Re:	[1157759-1] The Use of Collaborative Synthesis [in Small-Groups] to Enhance the Co-Construction of Meaning in a Secondary Science Classroom

Thank you for submitting the New Project referenced below. The submission was handled by Expedited Review under the requirements of 45 CFR 46.110, which identifies the categories of research eligible for expedited review.

Title:	The Use of Collaborative Synthesis [in Small-Groups] to Enhance the Co-Construction of Meaning in a Secondary Science Classroom
Received:	November 17, 2017
Expedited Category:	*6 and 7*
Action:	APPROVED
Effective Date:	November 20, 2017
Expiration Date:	November 20, 2018

This action is included on the December 6, 2017 IRB Agenda.

No changes may be made to this project without the prior review and approval of the IRB. This includes, but is not limited to, changes in research scope, research tools, consent documents, personnel, or record storage location.

(907) 474-7800
(907) 474-5444 fax
uaf-irb@alaska.edu
www.uaf.edu/irb

Institutional Review Board

909 N Koyukuk Dr. Suite 212, P.O. Box 757270, Fairbanks, Alaska 99775-7270

October 15, 2018

To:	Leslie Patterson Principal Investigator
From:	University of Alaska Fairbanks IRB
Re:	[1157759-2] The Use of Collaborative Synthesis [in Small-Groups] to Enhance the Co-Construction of Meaning in a Secondary Science Classroom

Thank you for submitting the Continuing Review/Progress Report referenced below. The submission was handled by Expedited Review under the requirements of 45 CFR 46.110, which identifies the categories of research eligible for expedited review.

Title:	The Use of Collaborative Synthesis [in Small-Groups] to Enhance the Co-Construction of Meaning in a Secondary Science Classroom
Received:	October 8, 2018
Expedited Category:	*6 and 7*
Action:	APPROVED
Effective Date:	October 15, 2018
Expiration Date:	November 20, 2019

This action is included on the November 7, 2018 IRB Agenda.

No changes may be made to this project without the prior review and approval of the IRB. This includes, but is not limited to, changes in research scope, research tools, consent documents, personnel, or record storage location.

Appendix B: Instructional Procedures

The collaborative synthesis methodology used in this study has evolved and been applied with higher quality results in my teaching since 2014.

A core component of these co-constructive reading, writing and revising sessions is E.L Achieve's, **CM**® Constructing Meaning, Student Flipbook. The Student Flipbook provides sentence frames for various analysis tools used in literary analysis.

Stage A: Primary resource reading

Class time:

- 2 class periods

Materials:

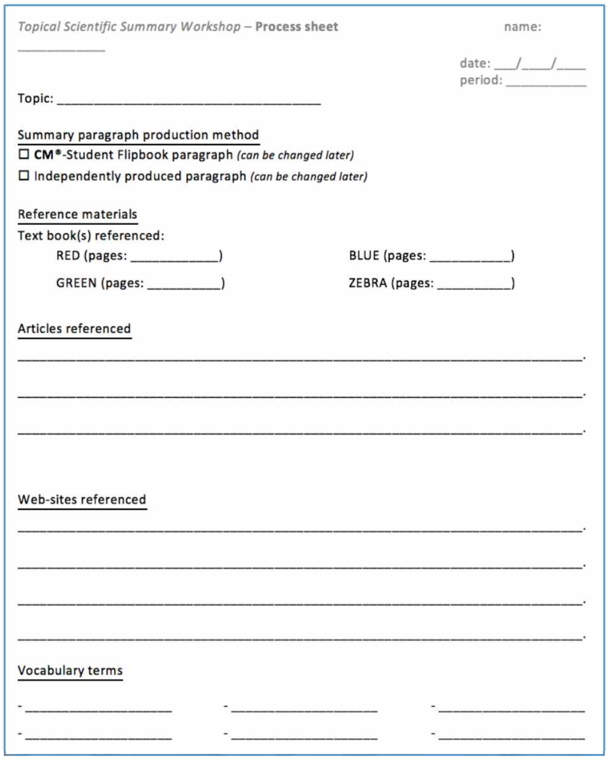
- *Newsela* articles/quizzes
- Chromebook laptop computers
- LYSD Student internet access and LYSD Student email

TR:

- Monitor *Newsela* article reading/formative assessment progress and provide guidance to additional resources to all learners, as needed.

TR whole class co-construction, facilitation

Preceding typical/traditional in-class instruction students will begin a new topic (e.g. cell structure, ecology, or planetary systems) by reading and completing reading quizzes on two to four, teacher-selected, topically appropriate, *Newsela* on-line articles. Following each reading will fill-in the **Process Sheet** data (Figure B-1) and vocabulary. Additional free-reading/note-taking reading follows with related textbook commentaries in any of our Glencoe Science (Red/Green/Blue or Zebra) textbooks. Time permitting, students will go on-line to research/take-notes on up to three topically-related web-sites. All resource materials will be logged on the learner's Process sheet. Student note-taking pages are available for use as a reference notes for future collaborative dialog stages and future assessment preparations.


Topical Scientific Summary Workshop – **Process sheet** name: ___________

date: ___/___/____
period: __________

Topic: ________________________________

Summary paragraph production method
☐ **CM®**-Student Flipbook paragraph *(can be changed later)*
☐ Independently produced paragraph *(can be changed later)*

Reference materials
Text book(s) referenced:
RED (pages: __________) BLUE (pages: __________)
GREEN (pages: __________) ZEBRA (pages: __________)

Articles referenced
____.
____.
____.

Web-sites referenced
____.
____.
____.
____.

Vocabulary terms
- ______________ - ______________ - ______________
- ______________ - ______________ - ______________

Figure B-1: Students log references and vocabulary used on their personal process sheet.

Stage B: Group Co-construction

Class time:

- 1 to 2 class periods

Materials:

- **CM**® Student Flipbook, Explain/Describe page (Figure B-2)
- Topical Science Summary Notetaking Sheet (Figure B-3)

TR tasking:

- TR will provide think-aloud assistance and model the initial paragraph drafting process a needed. For ease of process and to minimize eyestrain each learner holds an authentic copy of the **CM**® Student Flipbook during the drafting process.

TR whole class, facilitation

Using the whole class's combined topical knowledge and vocabulary we will brainstorm a paragraph template based on the **CM**® Student Flipbook, Explain/Describe sentence starters (Figure B-2).

CM Explain “Explanatory Paragraph” template

Explain and Describe

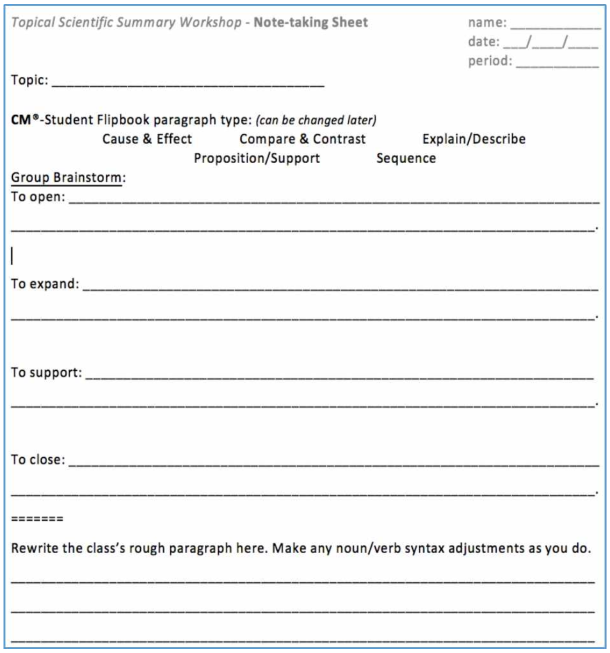
To open	▪ ______ is best described as _______. ▪ To define _______, it is necessary to understand ________. ▪ _________ is known for _______, and is important because _______.
To explain or describe	▪ ______ is an illustration of ______. ▪ ______ is frequently referred to ______.
To support your ideas	▪ Critical attributes of ______ include ______ and ______. ▪ A defining characteristic is _______. ▪ The key components are _______ and ________.
To close	▪ An explanation of ______ provides insight into ______. ▪ A complete definition of ________, allows us to _______.

Figure B-2: E.L. Achieve’s **C**onstructing **M**eaning® templates provide sentence frames for various writing functions.

Note: More comfortable learners may elect to develop a hand-draft an initial draft on their own. Those dyads are not representative of the larger group and may move forward through the process at a quicker, more independent pace.

To use the **CM**® Student Flipbook, Explain/Describe page the class employed the “three-finger voting system” with which learners choose which of the three “To open” sentence frames the group will complete. Using students’ notes if necessary, we work together on the SMARTBoard to select the appropriate terminology to fill-in their Note-taking Sheet data (Figure B-3). The students are the experts. They lead the process of producing this first draft. As teacher I modeled the process with them using think-aloud prompts and oral recasts of the written words. Learners hand-write the developing sentence, in pencil, in their double line-spaced, Notetaking Sheet (Figure B-3).

Upon completion of the Whole Class Co-construction session using the four-sentence paragraph template, students hand-write the paragraph into the lower section of the class co-construction page.



Topical Scientific Summary Workshop - **Note-taking Sheet**

name: ___________
date: ___/____/____
period: ___________

Topic: ________________________________

CM®-Student Flipbook paragraph type: ***(can be changed later)***

Cause & Effect   Compare & Contrast   Explain/Describe
Proposition/Support   Sequence

Group Brainstorm:

To open: ____
____.

To expand: ____
____.

To support: ____
____.

To close: ____
____.

=======

Rewrite the class's rough paragraph here. Make any noun/verb syntax adjustments as you do.

____
____
____

Figure B-3: Collaborative synthesis note-taking sheet
(Whole Group Co-constructive writing step)

Stage C: Small-group Feedback

Class time:

- 1 class period

Materials:

- Notetaking Sheet, page 2 (Figure B-4)
- **CM**® Student Flipbook, Explain/Describe (optional)

TR tasking:

- Facilitate the Group Feedback process.
- Circulate between tables to number each learner's Small-group Feedback page 1 thru 4.

Table group work

Working together in table groups, learners will read from the bottom section of their Group Brainstorm pages. They will read each of their "To open" sentences aloud and choose which version (#1 thru #4) they feel is most fitting.

The process repeats as table groups select which version of each sentence ("To explain…," "to support…," "To close") they prefer.

Table groups rank their sentences from 4-star (most proud of this one), to 1-star (we like this one).

TR whole class, facilitation

Selecting a random table by lottery, TR requests their 4-star sentence and writes it on the board. Learners follow suit on their Small-group feedback page. TR moves around the class counter-clockwise to the next table group and each shares their 4-star sentence. If it's place has already been filled on the Small-group feedback page, they share their 3-star sentence. The process continues around the room, filling in the Small-group feedback page (Figure B-4).

Small-group Feedback:
Read your Group Brainstorm paragraph to your tablemates. When it is your turn to share, share your strongest sentence (the one your group is proudest of) with the class.

Write down all of the shared sentences from the SMARTBoard, here, in the spaces below.

To open: ____

____

Figure B-4: Collaborative synthesis note-taking sheet (Small-Group Feedback)

Stage D: Co-Construction (pair work)

Class time:

- 1 to 2 class periods

Materials:

- Notetaking Sheet, page 3 (Figure B-5)
- Process sheet, vocabulary list (Figure B-1)

TR tasking:

- Facilitate the paired co-construction process.
- Circulate between tables to ensure learners are on-task and not struggling with the assignment.
- Audio/video recording of collaborative pair work session.

Co-Construction (pair work):

Discuss the shared, Small-Group Feedback, paragraph with your partner. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic, together. Use any sentences you've seen or heard and modify them however you think best fits the topic.

Strongest option: Work together to create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Any phrases taken directly from articles must be underlined.)*

As you finish your paragraph, ***fine-tune*** it by test reading the text out loud to make it as smooth and easy to read as you are able. (*Note: You are invited to stand somewhere in the room and read out loud to your partner.*) You may rewrite your paragraph a second time to make it neater if you need to.

Figure B-5: Collaborative synthesis note-taking sheet (Co-Construction (pair work))

Collaborative pair work

Working together the assigned collaborative pairs will discuss the 4-star Small-group feedback that the class collected. Working together from this base paragraph the pair will synthesize the class's 4-star **CM**® Explain paragraph into a high quality, topical summary paragraph. They are not limited to its length, but the minimum is *six* sentences. Paragraphs are to include all necessary scientific vocabulary and their definitions if necessary for the pair's comprehension.

Stage E: Individual summary

Note: Due to the numerous unexpected school and weather-related delays the poster-related stages, Stages E, F, and G, were abandoned (formally) for this project.

Class time:

- 1 to 2 class periods

Materials:

- Notetaking Sheet, page 4 (Figure B-6)
- Process sheet, vocabulary list (Figure B-1)

TR tasking:

- Facilitate the personal summary process.
- Circulate between tables to ensure learners are on-task and not struggling with the assignment.
- Audio/video recording of personal summary work session.

Personal summary: On your own (independently), write *your personal version* of the most correct paragraph here. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic. Use any sentences you've seen or heard and modify them in the way you think best explains the topic.

Strongest option: Create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Phrases taken directly from articles must be underlined.)*

Figure B-6: Collaborative synthesis note-taking sheet (Personal summary)

Personal summary work

Working independently from their collaborative pair summary paragraph and any previous in-class paragraphs, each learner will synthesize a personal topical summary paragraph. They are not limited to its length, but the minimum is *six* sentences. Paragraphs are to include all necessary scientific vocabulary and their definitions if necessary for *reader* comprehension.

Stage F: Small-group poster project

Class time:

- 1 to 2 class periods

Materials:

- Notetaking packet (all sheets)
- Process sheet, vocabulary list (Figure B-1)

TR tasking:

- Facilitate the collaborative poster production process.
- Circulate between tables to ensure learners are on-task and not struggling with the assignment.
- Audio/video recording of collaborative poster production work session.

Table-group work

Working as a table group from their personal summary paragraphs, each table-group will produce a presentable poster explaining their topic.

Note: Each member will actively participate in the poster presentation. Note cards will be used, and there will be guests in the room during the presentations.

Poster will include

- a title,

- a sketch or drawing that generally characterizes the topic,
- a brief written explanation of the topic (not their paragraph sentences),
- a listing of the participant's names and tasks (attached to the back),
- presenter notecards.

Stage G: Small-group poster presentation

Class time:

- 1 class period

Materials:

- Personal presentation note cards
- Presentation evaluation sheets

TR tasking:

- Facilitate the collaborative poster presentation process.
- Audio/video recording of collaborative poster production work session.

Table group work

Presenting from their personal note cards each table-group will explain their topic in 3 - 5 minutes. Each member will actively participate in the poster presentation. Note cards will be used, and there will be guests in the room during the presentations.

Appendix C: Students' Written Artifacts

All student writing artifacts referenced within this paper appear in this appendix. Student's science writer's workshop packet writing pages are presented numerically by group and alphabetically by name. The following entries are included herein:

Group 1: Writing excerpt C-1 through Writing excerpt C-7 contain the work of Harry (Stages A and D), Matt (Stages A and D), and Stu (Stages A and D).

Group 2: **Error! Reference source not found.** through Writing excerpt C-11 contain the work of Helen (Stages A and D) and Tommie (Stages A, C, and D).

<Student writings begin on the following page>

Group 1

Harry's writing

Harry 02

Rewrite the class's brainstorm paragraph here, in your words. Make any sentence adjustments that feel right to you as you rewrite the class brainstorm sentences. Does that make sense?

Mitosis is best described as cells produces more DNA marterial.

Mitosis is frequently referred to as body cell reproduction.

A defining characteristics is a cycle of repeating the same way once.

Mitosis begins when interphase begins. IPMAT Cytokenosis follows IPMAT.

The next stage was (is) prophase. Cell groups mature/ prepares for mitosis.

The next stage for mitosis is metaphase. The chromatids align along equator the cell in metaphase.

Chromatids separate and move to ends for anaphase

Last but not least the final stage for metaphase is telophase the cytoplasm is beginning to separate.

3

Writing excerpt C-1: Harry's Stage A writing.

<Harry mistakenly continued his Stage D writing atop his Stage C writing on this page.>

Harry 03

Edit the small group paragraph here, rewriting it in your own words. Make any sentence adjustments that feel right to you as you rewrite our small groups' sentences. Does that make sense?

mitosis is best described as the division of cells.
mitosis is frequently referd to the body cell reproduction.
The division of cells is a cycle that allways repeats in the same order.
Mitosis begins when Interphase start IPMAT, Interphase, Prophas, Metaphase, Anaphase telophase, cytokiniesis is at the last (word) of mitosis. Interphase is duplicated chromosomes copied. Prophase cell grows mitosis preps for mitosis. Metaphase with the chromatids allign along the equator of the cell. The fifth cell stage for mitosis is anaphase and the chromatids divide and move to the ends. The second to last stage is telophase which the cell's with new and duplicated DNA and heredity material.
Cytokinesis is part of mitosis and the last stage with duplicated material.

5

Writing excerpt C-2: Harry's Stage D writing.

Matt's writing

Matt 02

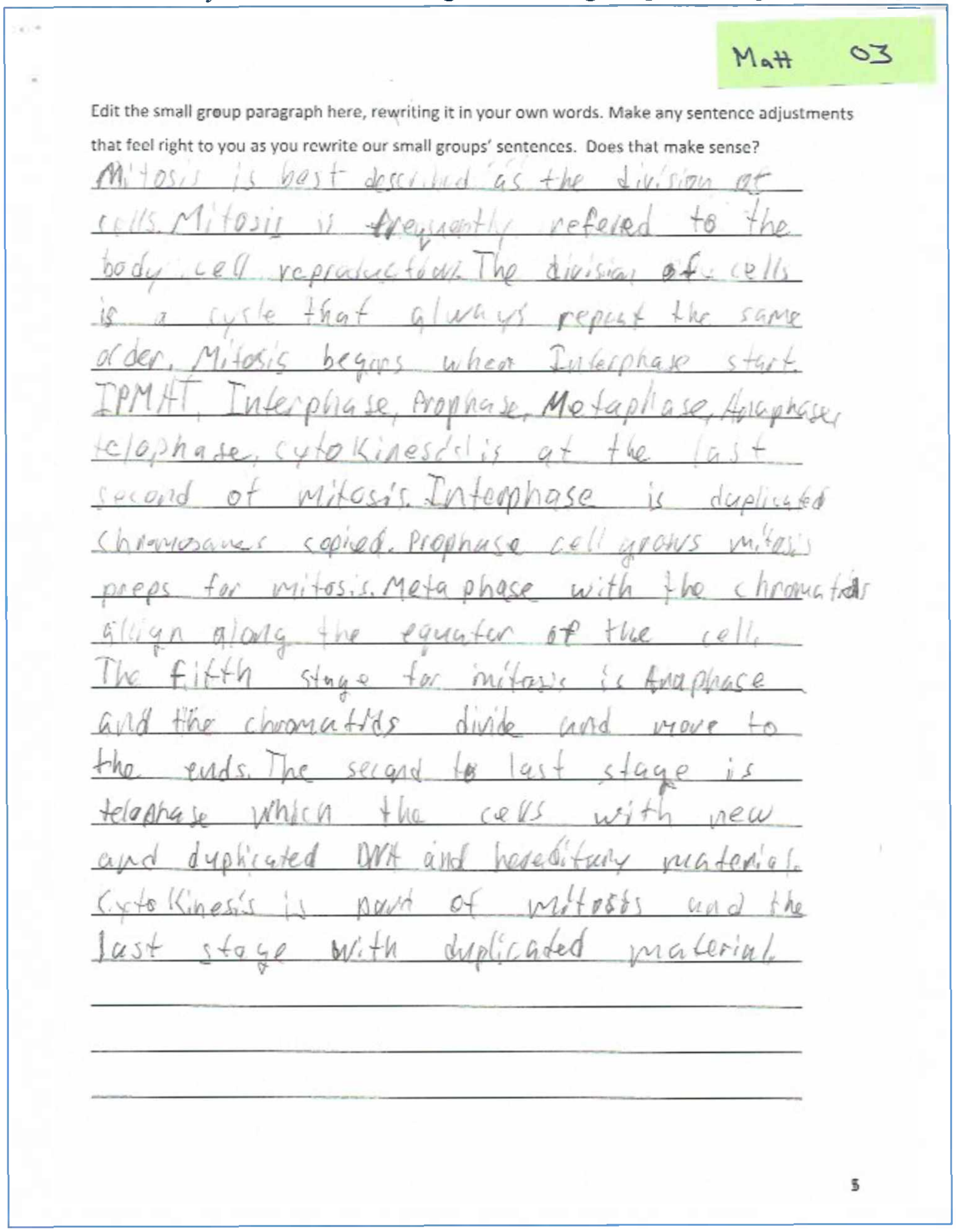
Rewrite the class's brainstorm paragraph here, in your words. Make any sentence adjustments that feel right to you as you rewrite the class brainstorm sentences. Does that make sense?

Mitosis is best described as cells replicating ~~make DNA and~~ hereditary material. Mitosis is frequently referred to as body production. A defining characteristics is a cycle repeating itself the same way once. Mitosis starts when interphase begins. IPMAT: Interphase, prophase, metaphase, anaphase, and telophase. Cytokinesis follows IPMAT. The next stage is prophase. Cell graups mature/prepare for mitosis. The next step for mitosis is metaphase. The chromatids align along the equator the cell in meta phase. The continuing phase is Anaphase. In the phase of anaphase as the chromatid separate and move to the end. The second-to-last phase is telophase. In the following phase the cytoplasm starting to depart. The last phase is cytokinesis. In this phase a new cell has been made

3

Writing excerpt C-3: Matt's Stage A writing.

<Matt mistakenly continued his Stage D writing atop his Stage C writing on this page.>



Matt 03

Edit the small group paragraph here, rewriting it in your own words. Make any sentence adjustments that feel right to you as you rewrite our small groups' sentences. Does that make sense?

Mitosis is best described as the division of
cells. Mitosis is frequently refered to the
body cell reproduction. The division of cells
is a cycle that always repeat the same
order. Mitosis begins when Interphase start.
IPMAT, Interphase, Prophase, Metaphase, Anaphase,
telophase, cytokinesis is at the last
second of mitosis. Interphase is duplicated
chromosomes copied. Prophase cell grows mitosis
preps for mitosis. Metaphase with the chromatids
allign along the equator of the cell.
The fifth stage for mitosis is Anaphase
and the chromatids divide and move to
the ends. The second to last stage is
telophase which the cells with new
and duplicated DNA and hereditary material.
Cytokinesis is part of mitosis and the
last stage with duplicated material.

5

Writing excerpt C-4: Matt's Stage D writing.

<Matt completed his Stage D writing on the Stage C page, above.>

Matt 04

Co-Construction (pair work):

Discuss the shared, Small-Group Feedback, paragraph with your partner. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic, together. Use any sentences you've seen or heard and modify them however you think best fits the topic.

Strongest option: Work together to create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Any phrases taken directly from articles must be underlined.)*

As you finish your paragraph, *fine-tune* it by test reading the text out loud to make it as smooth and easy to read as you are able. (*Note: You are invited to stand somewhere in the room and read out loud to your partner.*) You may rewrite your paragraph a second time to make it neater if you need to.

Mitosis is best described as the division of cells.

=======

6

Writing excerpt C-5: Matt's Stage D writing (unused page).

Stu's writing

Stu12 02

Rewrite the class's brainstorm paragraph here, in your words. Make any sentence adjustments that feel right to you as you rewrite the class brainstorm sentences. Does that make sense?

Mitosis is best described as the division of cells. Mitosis is frequently refered to the body cell reproduction. The division of cells is a cycle that always repeats in the same order. Mitosis begins when interphase starts. IPMAT, Interphase, Prophase, Mela plase, Anaphase, Telophse, Cytokenesis is at the last second of mitosis.

3

Writing excerpt C-6: Stu's Stage A writing.

<Stu mistakenly continued his Stage D writing atop his Stage C writing on this page.>

Stu12 03

Edit the small group paragraph here, rewriting it in your own words. Make any sentence adjustments that feel right to you as you rewrite our small groups' sentences. Does that make sense?

Mitosis is best described as the division of cells.
Mitosis is frequently reffered to the body cell
reproduction. The division of cells is a cycle
that alwas repeats in the same order.
Mitosis begins when interphase starts.
IPMAT, Interphase, Prophase, Metaphase, Anaphase
Telophase, cytokinesis is at the last second of
mitosis, Interphase, DNA is Duplicated
into a new cell, Prophase, the cells get ready for maturity,
once it matures it prepares for mitosis. Metaphase,
chromatids move and begin to align at the equator of
the cell. Anaphase, the cells begin to separate and
move to separate ends, it is a 50/50 seperation
of the cell material. Telophase, in the final stage
the cell is getting ready to seperate into
separat cells, this step will complete the
stages of mitosis. cytokinesis, this stage is
the completion of mitosis, and the cells
are succesfully two cells.

5

Writing excerpt C-7: Stu's Stage D writing.

Group 2
Helen's writing

Helen 02

Rewrite the class's brainstorm paragraph here, in your words. Make any sentence adjustments that feel right to you as you rewrite the class brainstorm sentences. Does that make sense?

Mitosis is known as cells that Can reproduce Certain amount of DNA Material But normaly Mitosis is Usually referred as Body Cell reproduction. The Cycle of Mitosis Can Only repeat the same way once. The steps are Interphase, Prophase Metaphase, anaphase and telo phase the way to easily remember these Steps is Called I.P.M.A.T also includes Cyto Kenesis. An addition to this The Next Stage is Prophase. During Prophase the cell reproduction Matures Then prepares for Mitosis. The next Stage of Mitosis is Metaphase. When Metaphase is active The Chromatids align together in the equator of the Cell. Chromatids Separate and Moves the ends for Anaphase. The final Stage for mitosis is telophase. The cytoplasm within the cell Begins to Separate. finally Mitosis starts back to Stage one. <3

Writing excerpt C-8: Helen's Stage A writing.

Helen 03

Co-Construction (pair work):

Discuss the shared, Small-Group Feedback, paragraph with your partner. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic, together. Use any sentences you've seen or heard and modify them however you think best fits the topic.

Strongest option: Work together to create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Any phrases taken directly from articles must be underlined.)*

As you finish your paragraph, *fine-tune* it by test reading the text out loud to make it as smooth and easy to read as you are able. (*Note: You are invited to stand somewhere in the room and read out loud to your partner.*) You may rewrite your paragraph a second time to make it neater if you need to.

Mitosis is known as cell reproduction repeating
the cycle of I.P.M.A.T, In addition to this
Cytokenisis is involved within I.P.M.A.T.
The stages of IPMAT are Interphase, Prophase,
Meta phase, Anaphase, Telophase and cytokenisis.
For the stages of I.M.A.T Interphase
DNA is copied Chromosomes duplicated.
Second Prophase cell growth/Matures prepares
for mitosis. Thirdly Metaphase chromosomes
align along equator of cell. forthly
* Ana phase Chromatids Separate and
Move to ends. lastly telophase in
the final step, the cytoplasm is
Beginning to Separate. I learned that
Mitosis Reproduces body cells

6

Writing excerpt C-9: Helen's Stage D writing.

Tommie's writing

Tommie 02

Rewrite the class's brainstorm paragraph here, in your words. Make any sentence adjustments that feel right to you as you rewrite the class brainstorm sentences. Does that make sense?

Mitosis is best described as cells producing more DNA material. Mitosis is reffered more to as body cell reproduction. Defining a characteristic is a cycle of repeating the same way once. Mitosis begins when interpase begins. IPMAT: Interphase, prophase, metaphase, anaphase, and telophase. Cytokenesis follows IPMAT. The next stage was prophase. Cell groups mature and prepares for mitosis. The next stage for mitosis is metaphase. The chromatids align along the equator while the cell is in metaphase. For anaphase, the chromatids separate and move to ends. Last but not least, the final stage for mitosis is telophase. The cytoplasm is beginning to separate.

3

Writing excerpt C-10: Tommie's Stage A writing.

Tommie 04

Edit the small group paragraph here, rewriting it in your own words. Make any sentence adjustments that feel right to you as you rewrite our small groups' sentences. Does that make sense?

Mitosis is best described as cells reproducing more DNA material. Mitosis is reffered more to as body cell reproduction. Defining a characteristic is a cycle of repeating the same way once. Mitosis begins when interphase begins. IPMAT: Interphase, Prophase, Metaphase, Anaphase and Telophase. Cytokenesis follows IPMAT. The next stage was Prophase. Cell groups mature and prepares for mitosis. The next stage for mitosis is Metaphase. The chromatids align along the equator while the cell is in metaphase. For Anaphase, the chromatids separate and move to ends. Last but not least, the final stage for mitosis is Telophase. The cytoplasm is beginning to separate. The first stage for mitusis is Interphase. Mitosis begins when interphase begins. DNA is copied and chromosomes duplicate for interphase.

5

Writing excerpt C-11: Tommie's Stage C writing.

Tommie 05

Co-Construction (pair work):

Discuss the shared, Small-Group Feedback, paragraph with your partner. Remember to apply all of the scientific language that you believe will help you get your point across to the audience.

Strong option: Construct a new, more descriptive paragraph describing the topic, together. Use any sentences you've seen or heard and modify them however you think best fits the topic.

Strongest option: Work together to create a completely new paragraph. You may choose useful words or phrases from any of the articles. *(Any phrases taken directly from articles must be underlined.)*

As you finish your paragraph, *fine-tune* it by test reading the text out loud to make it as smooth and easy to read as you are able. (*Note: You are invited to stand somewhere in the room and read out loud to your partner.*) You may rewrite your paragraph a second time to make it neater if you need to.

Mitosis is known as cell reproduction repeating the cycle of IPMAT. In addition to this cytokenesis is involved within IPMAT. The stages of IPMAT are Interphase, Prophase, Metaphase, Anaphase, and Telophase. For the stages of IPMAT, Interphase, lets chromosomes dulicate. Prophase prepares for mitosis and lets cells mature. Chromatids align along equator of cell or Metaphase. For Anaphase, chromatids separate and move to ends. In the final step. Telophase, the cytoplasm is beginning to separate. Mitosis is frequently reffered to as body cell reproduction. I learned that mitosis reproduces body cells.

=======

6

Writing excerpt C-12: Tommie's Stage D writing.